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The Relations of Chemistry to Industrial Progress:

AN ADDRESS

DELIVERED BY

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RELATIONS OF CHEMISTRY TO INDUSTRIAL PROGRESS.

By H. W. Wiley.

THE demands of modern times are extremely practical. This state of affairs is nowhere seen with greater distinctness than in their relations to higher education. The young man of to-day not only wants to learn, but in acquiring knowledge desires to get something which will be of use to him in life. All of our higher institutions of learning have recognized this condition and adapted themselves to it. Naturally, in high schools and academies this tendency does not have free scope for development, but even in those places its effects are marked. The youth who attend a high school or academy either expect to finish their education with that course or

to fit themselves for advanced courses in colleges or universities. It is not unusual, therefore, to find the elective system introduced into a high school or into an academy, and to see at least two courses presented for choice. In one of these the leading motive is to provide the student with a somewhat liberal education, with the expectation that it is not to be continued in any other institution. In the second course the principal aim in view is to fit the students for a higher course of study in a college or university.

I believe in this State there is an arrangement whereby the graduates of certain high schools, whose courses of instruction are arranged in conformity with a certain plan, are admitted without further examination to the higher institutions of learning in the State. The influence of this plan is seen to a greater or less extent in all the fitting institutions of the country, although those who hold the certificates of these institutions are required to undergo the examination for admission which is set for all applicants for entrance into the older universities. In many high schools, even outside of the city of Boston, it is considered a

matter of congratulation when their graduates successfully pass the examinations set for Harvard and Yale.

At the request of Dr. Smart, I have chosen a theme for discussion on this occasion which has intimate relations to the practical side of education. I have not been quite brave enough to address myself to the task of discussing the subject as at first proposed, viz.: The relations of science to industrial progress. A subject so broad could hardly be discussed in an adequate manner in the brief space allowed for this address, and even if it could be, I should not feel equal to attempting it. I think I shall find plenty of scope for the remarks I make, and the applications of them, without going very far outside of the domain of my own science, or, indeed, that special branch of it to which I have devoted the best years of my life.

It is but natural that teachers of science should seek to so arrange their work as to secure, in so far as possible, the highest practical training consistent with the more important duty of education, viz., the training of the mind. In other words,

those branches of practical instruction which have also a high value as educational means, are to be preferred in arranging a curriculum for a high school, college or university.

I am not one of those who have words of condemnation for the old methods of instruction. In my own history my years of student life were spent during that transition period which marked the passage from the old to the new methods. When we consider for a moment the high scholarship and the great mental attainments of those men who were moulded under the old system we can not find any just cause for condemning it. In fact, for many purposes and for many men, the old ironclad system of instruction had many advantages over the new flexible methods. It prevented, for instance, the abnormal development of peculiar fads or fancies, of which the student might be possessed. I am not prepared to say that the old system of education prevented the development of cranks, but it was not especially designed to foster the vitality of that genus. After nearly a quarter of a century spent in

active scientific work I am more than ever decidedly of the opinion that the old-fashioned college education in mathematics, the dead languages and so-called philosophy affords the very best possible preliminary education for scientific work.

I believe, however, that this training should come earlier in life than it did in former times. The talent, for instance, of acquiring languages is natural to extreme youth and the teaching of Latin and Greek to boys should begin when they are ten instead of eighteen years of age.

To illustrate the profound impression which the demands for industrial education have made upon our higher institutions of learning, I may cite a few instances of events which have happened near home. Until the year 1873, with the exception of instruction in qualitative analysis at Earlham, no laboratory instruction to students in chemistry was ever given in any college in Indiana. It is true that many of our institutions had most excellent courses of text-book instruction and in some cases of experimental lectures. When I was a student of Hanover College I listened to a course of experimental lectures in

chemistry given by Dr. Scott, of revered memory, which, when the meagre supplies at his command are considered, were the most remarkable that I have ever heard. With an amount of apparatus which even the great Berzelius would have deemed poor and meagre, and with scarcely any mechanical facilities, he performed many difficult and brilliant experiments illustrating the principles of chemistry and of chemical philosophy. I recall especially one experiment which he made during every course in showing the method of manufacturing and exploding that most dangerous compound—chloride of nitrogen. In this difficult and dangerous experiment, Dr. Scott was uniformly successful, and I have never anywhere else seen any lecturer on experimental chemistry attempt to perform it. Equally good work was done in many of the other institutions of the State, among others by three gentlemen whose acquaintance I had the good fortune to make later in life, viz.: Dr. Tingley, at Greencastle; Dr. Campbell, at Wabash; and Dr. R. T. Brown, at Indianapolis. But these gentlemen

had no facilities for extending experimental instruction beyond the lecturer's desk.

The first desks for students' laboratory work in chemistry were built in the old Northwestern University, now Butler, in the autumn of 1873. In October of that year, ten students, or about that number, were put to work in experimental chemistry.

In the autumn of 1874 were built the desks which, I believe, are still in use in the old chemical laboratory of this institution. It may seem almost incredible to teachers and students of chemistry in the institutions of this State, at the present time, to be told that the methods of laboratory instruction, now so universally employed in the chemical laboratories of our colleges, a little over twenty years ago were utterly unknown.

The case is even more striking when we consider electricity in its practical bearings, as electrical engineering. In the autumn of 1876, the first electric light generated by a dynamo ever seen in the United States, outside of Philadelphia, was exhibited in the old chemical laboratory of

this institution. I believe the old Gramme machine which generated this current is still doing good work in the laboratory of electrical engineering. The exhibition of electric lights at that period caused almost as much comment and excitement as are to-day seen in the photographic representation of bodies wholly invisible by ordinary light. I hope that this old Gramme machine may, on account of its historic interest, be always carefully preserved in the physical laboratory of this university.

I mention these instances simply to show, by the sharp contrast between the character of higher education a quarter of a century ago and at the present time, the remarkable impress which the demands for modern industrial education have made upon our systems of learning. The old nucleus of education may still be found, perhaps, to be the vital center and core of all, but the great energies of education and the great expenditures therefor are made in new directions and for new purposes.

We realize more vividly than in the earlier days that we live in a visible world. We know

that our young men when they leave college, and even sometimes when they are in it, have to meet hard knocks and straitened circumstances, and that their equipment, mental and physical, must prepare them for great endeavors and long endurance. In this direction we have seen another marked change permeate our educational methods. In all our great institutions of learning the authorities in charge have recognized the fact that the students have bodies, and that physical strength, health and endurance are factors of prime importance in education and in active life. Twenty-five years ago no attempt was made in any higher institution of learning in this State to cultivate the physical prowess of its students. In not a single college in Indiana could we find a boat crew, a base-ball nine, a company of cadets or a foot-ball eleven. The first gymnasium ever erected in an Indiana college was built in 1874 at Purdue University, and it was but little used. I can remember the time when it was not considered dignified for a college professor to encourage physical pursuits, and it was absolutely horrifying for him to engage in them.

I myself once had the honor of being cited to appear before the honorable Board of Trustees of Purdue University to be tried for conduct unbecoming a professor. One of the charges to which I had to answer was for playing base ball in knee breeches, and the other was for riding a bicycle in a similar costume. In those days any display of calves was considered particularly vealy. I remember still with feelings somewhat tinged with fear, of the astonishment of the President of Wabash College, who, having come to visit what was then the famous students' laboratory of Purdue, was compelled to wait until a match game of base-ball was finished before the professor of chemistry could have time to show him around. Fortunately, in those days I escaped the condemnation of the authorities for having organized a company of cadets among the students and for serving as its instructor in military tactics.

I believe this is all changed here now; that you are proud of your foot-ball eleven, except on certain Missouri occasions; that it is not considered a bar to polite society to belong to a base-ball nine,

and that some of your professors have consented to lay aside their dignity in so far as will permit them to serve on the athletic committee.

I have thought that I could in no better way present the claims of science to the consideration of teachers and the public than by pointing out briefly some of the relations of chemistry to industrial progress. It seems to me that industrial progress and civilization are synonymous terms. The humanities which together constitute civilization depend for their vitality on the industries which make humanity possible. Every branch of human industry in its development brings new ideas and reveals new facts, and helps to make man more and more independent of the servitude of tradition and authority. In so far as the human race removes itself from the crudities of superstition, from the incubus of dogma and from the persuasion of authority, just in so far is it emancipated and civilized. Men very naturally and very honestly disagree in respect to the activity of those causes which have helped the human race forward. Most of us accept the theory of evolution to account for the diversity and development

of life, but when reason, education and religion appear, they serve to counteract the forces which have produced evolution and, in fact, to undo much of the work which the uninterrupted operation of natural law has performed. The tendency of civilization is therefore almost directly in opposition to those forces which have made humanity possible. As an illustration of this, attention may be called to the grand system of organized philanthropy which is found in every civilized community. The care which we bestow in public and in private on the old, the imbecile and the sick secures precisely what the great forces of evolution would eliminate and destroy. Were it not, then, for other forces to counteract the deteriorating effects of philanthropy, the human race, through its own excellence of heart, would rapidly regress. Fortunately, therefore, in the progress of human industry we find a factor which tends to correct or neutralize the enervating effects of philanthropy. The necessity of effort and the pleasure of labor drive men into pursuits which develop their faculties, increase their power, and eliminate, to a certain degree, the deteriorating

effects of care, of helpfulness, of sympathy and affection.

In this respect the progress of industry must be regarded as the great helper of humanity. Just in proportion as the industries of a nation broaden and develop, just in that proportion does the character of its citizens gain strength and their brains and muscles skill and power.

Under the action of recently enacted laws regarding imports into the United States, each package of imported foreign goods is labeled with the name of the nation in which it was made. To stand in our custom houses and inspect imported products is one of the best lessons illustrative of the relations of chemistry to the industries which can possibly be given. Even the observer who is not looking for any particular purpose will be struck with the number of packages labeled "made in Germany." If he should, in the pursuit of any investigation, look into the nature of these packages he will find that they represent pre-eminently the products of chemical industry.

We are accustomed to think often of German progress in connection with the works of their

great philosophers, such as Kant and Hegel; of their great poets, such as Schiller and Goethe; and of their great statesmen and generals, such as Bismarck and Moltke, but if we investigate more closely the causes of the wonderful strides which Germany has made in all directions we will find that it is not due to the mystified and inexplicable ponderous phrases of their philosophers, nor to the beautiful and descriptive verses of their poets, nor yet to the system of federation and the great victories due to their statesmen and warriors. On the other hand, we will find that this progress is due directly to the system of instruction in science, which during the last hundred years has permeated all parts of the German Empire, dominating the faculties of its universities and absorbing all the energies of its technical schools. And among the sciences whose teachings have made this great progress possible chemistry easily stands at the head.

Directly springing from the instruction given in the universities and technical schools have grown the great industries which have pushed the German people to the forefront in many of

the leading pursuits of civilized life. A marked illustration of this is found in the industry of dyeing. First through the discoveries of the great Hoffmann and afterwards by the investigations of other chemists, the dyeing interests of the world have been completely revolutionized. From that most unpromising substance—coal tar—at one time considered an almost worthless residue of the manufacture of gas, nearly all the colors which now find a use in the arts have been derived. Again, we see in the development of the beet sugar industry in that country an illustration of the immense industrial importance of pure and applied chemistry. On a soil not naturally fertile and exhausted by twenty centuries of agriculture and in a climate not of the most hospitable kind, chemical science has developed a great industry which successfully competes with the warmth of climate and fertility of soil of the most favored tropical regions. Last year the German Empire produced nearly two million tons of sugar, a quantity as great as that produced by the whole world a little over a quarter of a century ago.

No wonder, therefore, that the artisans of England and America look with feelings of distrust at the packages marked "made in Germany" with which our customs storehouses are burdened.

I am not one of those who would value a science solely according to the dollars and cents which it brings. I am a believer in pure science, that is, in that class of investigations carried on solely for the discovery of the unknown without any reference whatever to their commercial value. Every fact which is discovered and every truth which is made known have, however, a value whether measured by dollars and cents or not. I am even willing to see Nansen fasten his boat in an ice floe and float, heaven knows where, in the hope that some favoring current will carry him to the boreal apex of the earth. It may be that when at last some man does stand at the North Pole it may not prove of any advantage whatever, even to the festive polar bear, but nevertheless even such a discovery as this is worth making. And so it is with every other science. There are thousands of facts which are discovered which seem to have no interest, near or remote, to the

welfare of humanity, and yet the discovery and recording of these facts must sometime and somehow prove useful.

In chemistry we have many illustrations of this idea. Many years ago Prof. Crookes, by producing a vacuum far greater than had ever been accomplished before, discovered certain properties of energy which he called radiant matter. For nearly twenty years Crookes tubes have been a physical toy devoted more to the entertainment than the instruction of classes in light, heat and electricity. The vanes of mica, blackened on one side and revolving without any apparent cause, seem to be almost a realization of the chimera of perpetual motion. With wonderful skill and ingenuity Prof. Crookes investigated the elusive properties of this fourth state of matter, a space from which almost all energy was excluded, save that of the unthinkable ether itself. Who, even a few months ago, would have supposed that these truly marvelous researches of Crookes could possibly have any direct influence upon men and things? Yet we see now through the marvelous discovery of Prof. Roentgen an application of

Prof. Crookes' discovery, which, in its possibilities of benefit to suffering humanity, has not been surpassed by any single invention of the last hundred years. At last we are able, by means of the force not yet defined, emanating from vacuous space under the influence of electrical excitation, to delineate the forms of concealed bodies which can not be reached by any ordinary effects of light. A shadow of the bones of the human skeleton, for instance, can be fixed upon a sensitized plate showing the character of fractures or the extent of abnormal growths. A bullet imbedded in the body can be outlined and the reflection is at once suggested that had this discovery come fifteen years earlier the character of the wound inflicted upon President Garfield might have been discovered, the murderous bullet extracted, and the life of the distinguished citizen and patriot saved for the welfare of his country.

An equally marked illustration of the benefits arising from purely scientific investigations, less striking only because so familiar, is the great discovery of Michael Faraday of the excitation of an electrical current produced by the movement of a

conducting body in a magnetic field. It is only a little over half a century ago since Faraday made his discovery. As a result of this observation, so apparently unimportant, we see to-day an entirely new curriculum of study in all of our great schools. The science of electrical engineering is a direct outgrowth of Faraday's observation. We have seen already a complete revolution in the methods of transporting passengers in cities growing out of this discovery. Rapidly are coming changes in the transmission of energy and in the utilization of the waste forces of nature. Torrents and cataracts are made to do valuable work for humanity hundreds of miles from their localities. A new system of illumination has sprung up over the whole civilized world, displacing oil and gas. It requires no prophet to foresee the day when the development of electrical energy, made possible by Faraday's discovery, will be accomplished far more economically than at the present, perhaps even permitting the direct conversion of burning fuel into electrical force. The very blizzards, which now sweep down upon us from the far northwest, and which no tariff nor quarantine can

stop at the frontier, will be made to warm and light the houses of our people, to mill their grain and drive their machines. Could there be a more striking illustration of what a discovery in pure science, developed by skillful technologists, can do in the promotion of human industry? It is true that neither the discovery of Crookes nor of Faraday belongs to what is now considered the domain of pure chemistry, but chemistry and physics are the same science. They require the same training, they investigate the same subjects, and both Crookes and Faraday are as much chemists as physicists.

It might be well to call your attention for a short time to a few points which, although they seem hackneyed, are yet suggestive. The development of chemistry along the lines of metallurgy has had a profound influence on human progress. Without metal working, civilization, as we understand it at the present day, would be impossible. Much has been made possible in the way of human advancement in the past half century by progress in the metallurgy of iron alone. It seems almost incredible, but it is nevertheless a

fact, that steel has been sold in the United States in the last few years at a price per ton which is often obtained for hay. Iron is the universal metal. It is found in every human trade, and devoted to every possible technical art. Steel, which is only a peculiar variety of iron, can be made almost as cheap as pig iron itself. Dominant in the arts of peace, as it is in the art of war, it rules every battle, whether of peace or war. It is doubtful whether any missionary effort, no matter how successful it has been, has had an influence on the development of humanity such as has been exercised by the Bessemer converter. Iron and steel are almost synonyms for progress and intelligence. It is not necessary to spend any time to show how intimately the science and art of chemistry are interwoven with the metallurgy of iron and steel. Every step has been made possible by the researches of the chemist, and every improvement in the application of chemical principles. I fear the great ironmasters sometimes forget the ladder by which they have climbed to fortune. The modest chemist in the laboratory of the steel works is

too often regarded as of the least importance, and receives far less wages and consideration than the assistant bookkeeper. While not germane to the subject which I am discussing, it may perhaps be well enough to call attention to this peculiarity in the industries of every nation. While these industries are admittedly based on chemical research and made possible by chemical technology, yet the chemists to whom they give employment are almost the poorest paid of any skilled artisans. At the present time, a series of articles is appearing in one of the German chemical journals discussing the admitted fact of the inferior social position of the chemist as compared with the soldier, the lawyer, the doctor and the preacher. In this country, fortunately, where democracy prevails, a chemist is just as good as anybody else, except graduates of West Point and Annapolis, and is received into polite society; but, strange enough, in that country most indebted to his genius and most dependent on his activity he is socially ostracized.

The progress which has been made in the manufacture of aluminum is another striking illustration of the practical utility of chemical research. A few years ago aluminum was kept as a rare specimen of a metal, and its high cost precluded the possibility of its commercial use. While among the most abundant of the elements of a metallic nature its high affinity for oxygen and the difficulty of securing ores suitable to reduction, rendered the manufacture of the metal impossible from a business standpoint. The advent of the electric furnace, however, opened up wide possibilities in metallurgy. The inventive genius of the chemist was not slow to utilize the new resources placed at his disposal. Among the first products were alloys of aluminum and copper, which in the form of aluminum bronze offered some extremely valuable products to the manufacturer. It was found that the properties of some of these bronzes were peculiarly fitted for certain materials requiring great tensile strength and resistance to pressure. Some of them possess a color and luster almost equal to gold. Processes for the electro-chemical manufacture of

the pure metal were rapidly multiplied, and while some of them possessed only a theoretical interest others assumed commercial importance. As a consequence the price of aluminum has rapidly fallen until it has reached a point which, in some instances, has been attained by as common a metal as copper. By reason of its lightness and tensile strength, aluminum is now widely used in the manufacture of culinary utensils and for other purposes.

We can confidently look forward to even greater advances in the production of aluminum, and its price will certainly fall until it reaches a limit which will make it possible to use it for the most important purpose to which it can be put, viz., in the building of bridges and other structures where the weight of the material entering into them is a factor of the most serious magnitude. For these structures, however, it is not probable that aluminum can be profitably used until it reaches a price which in relation to the price of steel is inversely proportional to the specific gravities of the two metals. The builder can afford to pay three or four times as much for aluminum for

bridge building as he can for steel. Whenever aluminum, therefore, can be placed upon the market at a minimum price of $160 per ton we may expect to see a revolution in the method of selecting materials for the construction of bridges and other structures of great size and weight. When this time shall have arrived the engineering difficulties which now attend the building of bridges over such streams as the North and East Rivers at New York will be so far diminished as to make the speedy construction of these works probable. Already we find aluminum entering into the structure of analytical balances, bicycles and other implements in which a combination of strength and lightness is highly beneficial.

It would be extremely easy to multiply instances of the value of chemical science and art in metallurgical operations, but this has been done so often and so ably as to make desirable the pursuit of some other theme illustrative of the text.

I would like to call your attention now to the great possibilities which have been opened in the way of industrial progress, due to the bridging of

the gap which was once supposed to exist between organic and inorganic compounds. At the present time there is no longer any line of demarcation between so-called organic and inorganic chemistry. All chemical compounds arise as a result of the action of certain natural laws, and the processes which determine the form of a crystal are no less vital than those which build the body of an animal.

One of the marked features of modern chemistry has been in the widening of the field of synthetic research. The building of a molecule requires far more skill than its destruction, and, therefore, as the knowledge of chemical principles has advanced and as the skill of the analyst has increased, it has been possible to put together the chemical elements into increasingly more complex and more valuable forms. Following out researches of this kind, the chemist has been able to produce by synthesis hundreds of compounds which a quarter of a century ago were supposed to be exclusively formed by the activity of the so-called vital forces. To such an extent has this been the case that in several instances the

old methods of producing certain chemical compounds through the medium of cultivated plants has been entirely abandoned. Perhaps the most striking illustration of this is in the case of the indigo plant. The cultivation of this plant and the manufacture of indigo therefrom were once profitable industries, but the manufacture of synthetic indigo and its substitutes in the chemical laboratory has so cheapened the price of this product as to render unprofitable the old processes. The indigo farms are therefore abandoned, and nearly the whole of the indigo of commerce is now manufactured by the chemist.

In the case of salicylic acid we see a similar development. If we had to depend upon the willow for our salicylic acid its reprehensible use as a food preservative would be far less extensive than it is at present. The observation made by Kolbe that this product could be made at small cost from carbolic acid has rendered the production of it on a large scale possible and made its world-wide use as a medicine and as a preservative perhaps too common.

In the synthetic production of aromatic ethers no less marked successes have been attained. By analytical methods it was discovered that the delicate aromas of flowers and fruits, the delectable flavors of old wines and whiskies, were due chiefly to the ethers formed from organic acids. By the artificial production of these ethers and their judicious mixing it is found possible to imitate the flavor and odor of the pineapple, the orange, the pear and the peach. The delicious fruit sirups expressly prepared from the fruits themselves, which we find advertised at the alleged soda fountains are, in most cases, the products of the chemical laboratory. The achievements of synthetic conquest have been pushed even to a greater extent and we find it possible to produce mixtures of ethers and essential oils, the pure fabrications of the chemist, which resemble in every respect the natural products arising from the aging of whisky and wine. With a half-dozen bottles of essences which you may purchase in Cincinnati, a barrel of alcohol which you can get from one of Uncle Sam's bonded warehouses, and a pound of burnt

sugar, which you can make yourself, you can in a few hours make two barrels and a half of ten-year-old Bourbon. In this day, when great universities spring up in a night, with all the facilities and appointments which centuries were supposed to produce, it is not so strange to find the chemist also annihilating time and obliterating space.

The ethers and the essences which have been mentioned are condiments rather than foods. They tickle the palate but do not nourish the tissues. The question arises, is it possible for the chemist to produce synthetically bodies which are true foods? The answer to this, from a theoretical point of view, must be in the affirmative. Many chemists have succeeded in accomplishing this synthesis. By a discovery which is yet only a few years old it is possible to pass directly from the elementary bodies to organic compounds. The most striking illustration of this is seen in the chemical union which takes place between calcium and carbon under the influence of the heat of the electric arc. These two elements, which have no tendency to unite

directly under any other form of treatment, are brought together in chemical union when subjected to the forces I have just mentioned. There results from this union a chemical compound known as calcium carbide, which has already received important applications in the arts. This body, so deceiving in its appearance, has all the apparent properties of an ordinary mineral. It is sometimes amorphous and sometimes crystalline in appearance, and in the neighborhood of an iron furnace it could be easily mistaken for worthless slag. But a remarkable chemical reaction occurs when this substance is brought in contact with water. Both bodies are decomposed. The oxygen of the water goes to the lime and the hydrogen unites with the carbon, forming a gaseous body, acetylene. This gas is also a product of the decomposition of organic bodies, and forms the starting point for their recomposition. Starting with this material, thus won directly from the inorganic elements of nature, a most interesting series of organic products can be formed, of which sugar, a highly nutritious food, is one. The process has not yet been well

worked out, and the final step of the formation of sugar needs still further confirmation.

But aside from the interest attaching to calcium carbide as a means of bridging completely the chasm between the domains of organic and inorganic chemistry, it has some most interesting industrial relations. Acetylene burns with a brilliant white light of high illuminating power and bids fair to supplant, to a certain extent, ordinary illuminating gas, especially in isolated localities where the city gas service does not extend. It is easily condensed into a liquid form, in which condition, in suitable cylinders, it is readily transported, and from which it is conveniently used for illuminating purposes. In the laboratory, also, it is highly useful where intense illumination is desired, and it can take the place of the lime or electric light for stereoptical purposes.

It is with some hesitation that I speak thus of acetylene, because some of the methods of its manufacture are controlled by patents and the country is flooded with schemes for floating the stock of acetylene illuminating companies. I

should, therefore, not be surprised, although very much chagrined, to find some of the statements I have made above used for advertising purposes, although it can not be said that the promoters of these schemes in all cases make light of their promises.

Working in entirely other directions and from a different standpoint, the chemist has been able to imitate and reproduce many of the sugars which naturally occur in plants, and, further than this, to determine the law of the series, to predict the possible number of sugars of each class which may exist and to actually verify his predictions by making many of them.

These instances are sufficient to show the possibilities which are open to the chemist for producing organic compounds. I am not one of those, however, who anticipate even in the remotest future that the art of the chemist will ever render unnecessary the profession of the farmer. It is not probable that any laboratory which man will ever construct will be able to compete with the cheaper processes of nature. The influence

of these researches, however, on the progress of industrial art can not be overestimated.

Along another line of research the beneficial effects of chemical studies, however, will be more markedly manifest. I refer to the public health. Great progress has been made in the last few years in our knowledge of the chemical activity of the microörganisms which swarm in every part of the universe. Many of these bodies exercise functions which are of the utmost utility to man, while the product of the activity of others is of an inimical nature. Who can measure, for instance, the ultimate benefit of the studies of that eminent chemist, lately deceased, Pasteur, to the welfare of man? Devoting his life to the study of the chemical activity of these invisible bodies, he discovered the laws of their existence and by a beautiful series of scientifically conceived experiments demonstrated the intimate relation which they bear to the vital functions of man. The essential element of the activity of microörganisms is oxidation, and the products of this oxidation become waste matters, which in some instances serve as foods and in others as

poisons. Among the poisons are found that large class of nitrogenous bases known as ptomaines, the effects of which on the vital organism resemble in many respects those of the poisonous alkaloids. To the effects of these microörganisms are due many of the diseases to which man is subject. Tetanus, smallpox, cholera, typhoid fever and consumption are some of the diseases in which the effect of these microörganisms has been traced. Acting on the hint given by the discovery of Jenner it has been shown that the system may be rendered in a certain sense immune to these diseases by inoculation. In just how far it may be possible to diminish the fatality which attends them it is yet too early to say, but as in the case of smallpox, it is just to infer that they may be robbed of many of their terrors.

These organisms have been found to exist in innumerable colonies in the soil. The soil is no longer regarded as dead matter, but in the highest degree as a vital organism. The possibility of growing plants has been found to depend directly upon the activity of the microörganisms of the soil. The progress of chemistry has thus

revealed in a new light the relations which it holds to the very base of society. If the activity of the microörganisms producing oxidations in the soil were destroyed for a single year, nearly the whole of the animal life of the earth would perish of hunger. Already practical results of immense importance have grown out of these achievements of chemical research. They have profoundly impressed the methods of agriculture and systems of fertilization. If pease or beans be planted in a sterilized soil the growth of the plantlet produced will be limited by the nourishment contained in the seed. After a few days of apparently vigorous evolution, during which time the reserve stores of plant food in the seeds have been consumed, the young plant will wither and die. But if before seeding in similar conditions the pea or bean be but pricked with a needle which has been in contact with the tubercles which are found on the roots of a normally growing plant, it will be found that the growth will not be arrested when the reserve food is exhausted, but will be continued with the usual vigor until the

plant has reached its full maturity. The wonderful facility of reproduction possessed by these vegetable microörganisms makes it possible to vivify the soil of a whole field from a sowing so minute as to be wholly invisible to the naked eye. It is not claimed, of course, that these processes of nitrification are the sole requirements of fertilization in the normal growth of plants, but the most abundant stores of organic nitrogenous matter and of free nitrogen may be present in the soil and in the ambient atmosphere and yet the plant perish from nitrogen hunger. It is in these cases that the introduction of a microscopic amount of seed containing the nitrifying organisms conditions the whole difference between total failure and abundant crops.

Experiments which are now conducting seem to indicate that there are great differences in the vitality and nitrifying ability of different nitrobacteria. It is the present work of the chemist to compare the activity of the nitrifying organisms existing in the soils of widely separated localities and to isolate, if possible, those which show the highest qualities. When this shall have been

accomplished, the novel practice will be seen of practical farmers inoculating their fields with minute capillary tubes containing a colorless liquid in almost an unweighably small quantity, in which are found invisible organisms by whose multiplication the fertilities of broad acres are to be increased. As the surgeon now prepares particles of virus, which, when inserted into the system, produce immunity from contagious disease, so the farmer, by a similar species of inoculation, will render possible in his soil the growth of organisms which will increase the quantity and value of his crops.

This idea has already been fully developed in the brewing industry. The character and quantity of the products of fermentation are determined by the use of ferments which are prepared by special cultures and freed from all deleterious and disturbing elements.

The brewmaster who allows ferments to grow at random in his cellars will soon find that the products of his work are deficient in flavor and purity and depreciating in price on the markets.

The yeast-maker is not only one of the most important, but should also be the most scientific of the employes of the brewery. The chemist has provided means whereby certain ferments injurious in their nature can be eliminated or have their functions reduced to a minimum, and this allows those, on the other hand, whose functions are of a favorable character to grow with vigor and without molestation.

In the dairy the immense practical importance of chemistry to industrial progress has received one of its most pointed illustrations. The character of butter and of cheese under given conditions is wholly dependent upon the nature of the ferments which grow therein. The so-called ripening of cream and of cheese consists solely in the development of active ferments and in the results of the oxidation which they produce. In a successful dairy the ferments which are favorable to the production of the best quality of cream and cheese are alone allowed to act. In a poorly kept dairy every kind of a ferment is allowed to grow at will, and the results of such a slipshod method of control are shown in the bad

character of the cheese and the rancid flavor of the butter which are produced. The development of the theory of fermentation and its application to so many practical purposes, led chemists to investigate the character of the organisms which were found to be active in the dairy. These studies led speedily to the isolation of the ferments of a favorable nature and to methods of destroying those which produced undesirable products. At the present day we find realized that condition of affairs which I have just alluded to as possible in the future of the fertilization of the soil. A bacillus which is capable of exciting the very best character of fermentation in cream has already been prepared in a pure state and can be delivered to the practical dairymen of the country. This minute and invisible particle of vital matter, when added to sterilized cream, sets up a fermentation which, in its results, produces the most delicious flavor that the best butter can have. A sample of cream thus inoculated is mixed with large quantities of ordinary cream, thus securing the proper fermentation throughout

the whole mass. As in the case of the best qualities of yeast, portions of these inoculated masses may be kept in cold storage from day to day, and thus the good qualities of the ferment be preserved for an indefinite time for future use.

In this manner a minute drop of liquid containing a few of the bacilli in question may serve to impart to thousands of pounds of butter, made during a considerable period of time, a most delicious and desirable flavor. The preserved portions of inoculated cream thus serve as starters for fermentation in non-inoculated masses. The practical dairyman will watch carefully the character of each churning of butter, a portion of the ripened cream being preserved from each. Whenever one is found of exceptional delicacy of flavor the portion of cream thus preserved is used as a starter for future fermentations. In this simple way the results of pure scientific investigation become the means of the greatest possible benefits in the industries of practical life.

I might, perhaps, speak of one other way in which the results of chemical work affect vitally the common interests of life. In the adulteration

of foods, unfortunately, the fraud is not always confined to matters harmless to health. Bad as any adulteration of an article of food or drink may be, it is not of the highest class of criminality when the fraudulent practices consist in the addition of harmless substances, but the health of the consumer becomes endangered when adulterations assume a poisonous character or are of a nature which by constant use will produce disturbances in the vital functions. Many bodies which have poisonous qualities are often introduced into foods either for the purpose of preserving them or of adding to the attractiveness of their appearance. Among preservatives which are commonly found, and which may be regarded as injurious, may be mentioned sulfurous and salicylic acids and borax. These bodies when taken in minute quantities and for short intervals of time produce no deleterious effects whatever. When, however, they are used for an indefinite period they tend to derange the digestive organs and impair health. Copper and zinc are often added to bodies which are preserved in a green state to fix the chlorophyll and prevent the

bleaching of the preserved products. Beans and pease preserved in a green state present a more attractive appearance when the green color is carefully preserved, and this is easily secured by the addition of copper or zinc. These bodies combine with the chloryphyll and fix it firmly within the vegetable tissues. No one would object to eating occasionally a small quantity of copper or zinc, but the continued ingestion of these bodies is reprehensible. The same remark may be applied to the use of eosin for giving a red color to substances like tomatoes or to the use of saccharin as a sweetener. The seemingly natural red color of preserved meats is secured by the use of niter and other similar objectionable agents. The practical results of applied chemistry in its relations to human health are seen in the certain means which it has devised for detecting and determining all additions and adulterations of the kind which have been mentioned.

In the matter of foods the chemist has also made investigations in another direction which are of the utmost importance to industrial progress. He has investigated, first, from a purely scientific

basis, the problems of nutrition. He has shown that certain characters of foods in the animal economy tend to produce certain results, and as a result of these investigations is able to prepare a ration which in any given case will meet the requirements desired. The pig which is fed for market requires quite a different ratio in the ingredients of its food principles from the cow that is fed for milk or butter. Three great food principles are recognized, viz., fats, carbohydrates and proteids. It is possible, by a judicious combination of these great food principles, to produce in any given case a ration which will secure the effect desired in the most economical way. By following rigidly the principles which have thus been established by scientific research, it is possible at the present day to prepare a hundred pounds of pork for market at a cost fully one-third less than was required by the haphazard method pursued a quarter of a century ago. It would not require much of a mathematician to calculate the financial benefits derived from that science which has made possible the saving of 33 per cent of the cattle foods of the country.

The principles just enunciated have not yet been rigidly applied in the administration of human foods. Especially is it the case with invalids and infants that foods are administered more in harmony with the magnitude of their advertisements than according to the scientific balancing of the nutritive ingredients which they contain. The pictures of sleek babies and the artful representation of assumed qualities in the public prints are more often consulted by fond parents in selecting the food of their children than are the opinions of the chemist and physiologist.

Wider fields of utility, however, open up before the possibilities of chemical investigation in the matter of human foods. If pigs deserve to be fed on balanced rations and steers stand in wait for the mandates of science before they chew their cuds, it is not too much to ask that man himself should receive some consideration. It is absurd to suppose that the student who struggles with the quandaries of quaternions and the youth who aspires to functionate as a center rush should haggle with the landlady about the price of the same hash. A ration of pickles and lead pencils,

which might be considered well balanced for the vandals of Vassar, would hardly be considered in place for the hoodlums of Harvard. The time is doubtless coming when the ration which is administered to man will be balanced on scientific principles for positive purposes. Just what changes will be necessary in this scientific feeding can not now be foretold, but there is no doubt of the fact that from the very first stages of infancy in the not remote future, men will be fed for the ministry, for medicine, or for the halls of Congress. In this latter case let us hope that the diet of lunar caustic, on which so many of our Senators and members in Congress have been lately feeding, may be wholly eliminated from the political ration, and the dishes of the statesman no longer have a silver lining.

The illustrations which I have given apply to one science only. It would not be difficult to draw similar arguments from all the sciences. It is not strange, therefore, returning to the theme with which this address was opened, to find the demands of modern times calling for a more extended scientific instruction. It is a question for

pedagogy and not for chemistry to discuss the relations of scientific teaching to the courses of instruction given in the primary and secondary schools. We should not rush into this matter in an inconsiderate way. Some of the sciences have long been a standard of instruction even in primary schools, and it is not unusual to find even young children instructed in the principles of physiology. It must not be forgotten, however, that the teaching of scientific facts is not teaching science. Children may learn by rote the names and numbers of the bones in the body, but no one would think of teaching anatomy in a primary school. They may learn something of the names and of the processes on which the vital functions depend, but a child can not study physiology. He may be told something concerning the constitution of the air, but none of us should forget the fact that two years ago even Lord Rayleigh and Prof. Ramsey didn't know that the atmosphere contained argon. Even in secondary schools it is doubtful if the true teaching of science can be properly undertaken, but it seems to me that there is no doubt of the fact that the data which have

been accumulated by science may be used to immense advantage in the secondary schools, both for increasing knowledge and for developing the mind. It is but reasonable, therefore, and in harmony with the march of events that our secondary schools are giving more time and attention to the dissemination of scientific data. For this purpose young men are taking courses in our schools and colleges of technology and in our universities. Hundreds of college graduates are annually entering the teachers' profession who have, during their college courses, really studied science. The great technical schools are, therefore, not only preparing young men to engage in active scientific pursuits in the industries and arts, but they are also preparing a corps of teachers who shall carry into the primary and secondary schools of the country a new enthusiasm and a new cult. It is not difficult to foresee the results which naturally follow from this course. Not only will the material interests of our youth in their preparation for the active duties of life lead them more and more into scientific pursuits, but they will

have as an additional incentive to their choice the example and accomplishments of their teachers.

There has been neither time nor occasion in this address to dwell upon the value of science training as a mind builder. This aspect of the question can be discussed far more effectively by the teacher than by one outside of that profession. I have already expressed a favorable opinion of the old classical methods of mind training, but that opinion does not exclude the idea of other methods which may be equally as valuable. Of one thing we may be quite certain, and that is that in the habits of careful observation and recording, which are necessary to the study of any science, the perceptive faculties of the mind receive a training which can not be regarded as inferior to that secured by any other method. In considering the data which are obtained by perception, the reflective faculties also obtain a training of the highest value. Teachers of science, therefore, must not be regarded wholly from a technical point of view, but must be entitled to a proper recognition from the pedagogic side.

We can not here enter into any discussion of the partition of the educational course among philology, mathematics and the physical and biological sciences. We simply recognize the fact of the value of the study of science as a mind builder, and admit that in that function it must continue to receive the favorable consideration of all educational boards.

In view of the facts which have been briefly set forth and the conclusions drawn therefrom, it is not difficult for us to explain the phenomenon of the increasing number of college and university students who elect the science courses of the curricula. It is a natural feeling in a young man to look forward to making his own living, and only a small percentage of our college students are relieved of the necessity of sometime providing for themselves. It is true that the ideal scientist is one who is relieved from all necessity of providing his daily bread and is left to ponder undisturbed on the great problems of nature, but idealism in this world is a thing seldom realized, and we must recognize the imminent and persistent necessity which shadows us and drives us every

day of our lives. The young man, therefore, is not only human but justifiable in selecting that course of training which not only allures him by its pleasure, but promises him also a living. It is true, as you may have gathered from what has been said before during this address, that the pursuits of chemistry do not often lead to fortune or to fame, but I believe as large a percentage of chemists as of any other profession are able to pay their board and rent. While the law, theology and medicine may present in some respects more attractive prospects, it is doubtful if they can promise a more pleasant or a more useful life than the pursuits of science.

We are face to face with the fact that the demands for technical education will increase. On every hand we find our schools of pure and applied science growing in a marvelous degree. In every branch of industry the demand for trained scientific men is rapidly increasing, and both State and private endowment of technical education has secured a promise of the continuity of that education in the future. But while we admit the justness of these demands for this

science training and provide for them, let us not forget that science is not the whole of education. Lay the foundations of the training of our youth broad and deep, in order that there may be built thereon a structure which meets the requirements of all practical needs and yet is both beautiful and enduring.

AMERICAN CHEMICAL SOCIETY

NORTH CAROLINA SECTION

ANNUAL ADDRESS

BY

CHARLES BASKERVILLE
PRESIDING OFFICER

CHEMICAL ECONOMICS

(DELIVERED IN RALEIGH ON FEBRUARY TWENTY-FOURTH, 1900)

PRESSES OF EDWARDS & BROUGHTON, RALEIGH
1900

CHEMICAL ECONOMICS.[1]

CHARLES BASKERVILLE.

In an article on "Fifty Years of Science in America," * this statement was made: "The contributions of Chemistry to knowledge and welfare during the half century have been many, yet relatively fewer and poorer than the rich returns from other sciences; and it is a conspicuous fact that few American names are connected with the greater advances of the science. While America's addition to astronomy, physics, geology and anthropology have been of the first magnitude, modern chemistry remains a monument to European genius almost alone. In connection with this fact—perhaps in explanation of it—it is to be noted there are no great chemical laboratories in this country, no institutions comparable with the astronomical observatories and geological surveys and natural history museums which have given prestige to American science."

In his Presidential address before the Philosophical Society of Washington, on "Chemistry in the United States," Dr. F. W. Clarke said: "A great mass of good work has been done, beyond question; but no epoch-making generalization, fundamental to chemistry, has originated in the United States, nor has any brilliant discovery of the first magnitude been made here. The researches of American chemists have been of high quality, but not of the highest; there is solidity, thoroughness, originality; but with all that, we can not be satisfied. The field is not exhausted; there are great laws

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[1]Address of Chairman North Carolina Section of the American Chemical Society, Raleigh, February 24, 1900.

*Dr. W. J. McGee in *Atlantic Monthly*, 82-316.

and principles still to be discovered; the statical conceptions of to-day are to be merged into wider dynamical theories; for every student there are opportunities waiting. Shall we do our share of the great work of the future, or shall it be left to others? Shall we follow as gleaners, or lead as pioneers? He who has faith in his own country can answer these questions only in one way"*

The history of chemistry in America is ably discussed in the paper from which the latter quotation is an excerpt. Chemistry has reached such a point in its growth that it is the gleaner who becomes the pioneer. Americans must needs learn before they could teach. They have gleaned from the master minds of Europe; they have come home and gradually constructed their laboratories until they rival those in Germany. During this endeavor for adequate equipment they have sent their students to Germany for training similar to their own. Now, however, we have such facilities offered our chemical students at the larger universities of America that it is no longer necessary to be dominated by German thought to be prepared to add our mite to the colossal structure of chemical knowledge. This gratifying fact comes home to us when we compare the number of doctors of philosophy in chemistry taken by Americans in Germany and America in the years 1889 and 1899. We confidently believe that the next half century will find us alongside any nation in the world in contributions to chemical knowledge, be it of whatever magnitude.

But your attention to-day is particularly directed to the technical phase of the subject—the practical application of the principles of chemistry toward the welfare of the general government. While it may not be the highest ideal and eventual goal of true education, namely the inculcation of the application of knowledge to personal or general gain, it can

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* *Science*, N. S., V. 117.

not be gainsaid that it is our direct object and duty to so train men and women that their lot in this life may be bettered or that they may aid others not so fortunate.

A comparison of the development and commercial growth of England and Germany is most instructive. "For the past three hundred years England has labored systematically to encourage all her sources of material prosperity. By special charters to commercial and manufacturing companies; by minutely elaborate laws governing apprentices, their terms of employment, and their wages; by high and often exclusive protective tariffs; by subsidies and by exclusive trading privileges granted to navigation companies; by the importation of skilled workmen from Holland; by receiving Huguenot refugees from France, and by the prevention of emigration of skilled mechanics; by her coal and iron deposits; by her early development of the steam engine and its application to the various industries, including railroads and steamships; by the industrious habits and the aggressive disposition of her people; by her honesty in governmental and business relations; by parliamentary commissions without number, and with a continuous and consistent policy on the part of the whole of England, she succeeded finally in absorbing most of the manufacturing, and in carrying nearly all of the commerce of the world." *

Germany—an inland confederation, the marvelous result of Bismarck's far-seeing policy—within twenty-five years rivalled England's hitherto unapproached commercial supremacy. England's concern was shown by the temper of the daily press and technical journals. Continued efforts of scientific men in public and the meetings of the various societies, aroused Great Britain from its serene security in the control of the world's commerce. A Royal Commission

* Presidential Address of Prof. J. B. Johnson before the Society for the Promotion of Engineering Education, 1898.

was appointed, and its report showed that there was not only much to fear, but more to learn. "Made in Germany" was a red flag, and despite their political and consanguineous relations the two great nations were, and are, at actual war.

Germany's marvelous commercial growth furnishes its own explanation. A well-defined policy was outlined and followed consistently. The end aimed at was high—the highest—rank in the commerce of the world—the means, to learn the best and make it, to invent the new and stimulate a call for it. "It is evident enough that no art or science can be known until learned, and to learn most rapidly and thoroughly one must be taught." The state provided the technical schools and the best instruction. The manufacturers appreciated the value of such scientifically trained individuals and employed them. It is not to our point to discuss the economic conditions and methods of education, production and distribution as followed by the German Government during this interval. Suffice it to say that Mr. Gastrell, the Commercial Attaché to Her Majesty's Embassy at Berlin, has seen fit to place the causes for Germany's commercial prosperity in the order given. *

We have adverted to the situation between England and Germany that we might secure a better perspective of the position we occupy in regard to these two powerful nations, by which comparison we locate ourselves in the commerce of the world.

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* From Diplomatic and Consular Reports to the British Government, January, 1899.

We shall confine ourselves to the past decade only as facts gleaned from such a retrospect bear directly upon our theme.

*In 1889 our Imports (dutiable and free) amounted to		$745,131,652
	Exports (domestic and foreign)	742,401,375
	An excess of imports by	2,730,277
In 1898 our Imports (dutiable and free) were		697,148,489
	Exports (domestic and foreign)	1,227,023,302
	An excess of exports	529,874,813

Again	1889.	1898.
Merchandise imported for consumption, per capita, was	$12.10	$7.89
Reduction 35 per cent.		
Exports per capita	11.92	16.27
Increase 27 per cent.	*Per Cent.*	
Products of manufacture, percentage of total	18.99	24.02

To put the matter in another shape and draw comparisons: the total values of our manufactures exported have increased by 110 per cent. Since 1890 (earliest date for which data are obtainable) Great Britain has had no increase. Some figures are appended for other nations.

1887–1896.	
Germany	13 per cent.
France	10 "
Switzerland	6 "
Netherlands	3 "
Great Britain	----------
Austria-Hungary	Decrease.
Russia	Decrease.
United States, increase	110 per cent.

The greatest increase in our exports has been in metallurgical products. In 1889 metals constituted 20 per cent of our exported manufactures; in 1898 over 44 per cent. The increase in the amount of our exports in metals has been 339 per cent, while the increase in other manfactures than metals has been 55 per cent. (Complete figures for 1899

*From Summary of Commerce and Finance for May, 1899, Treasury Department, Washington.

were not obtainable, but the indications point to an increase even more noteworthy.)

The Chief of the Bureau of Statistics states in his report for 1898, "The history of nations and peoples shows that groups of people frequently excel in certain industries, and the growth of our exportation as well as our domestic production of manufactures seems to point to metals as our most successful line of work, at least at the present time." There are some things that on account of lack of raw material or great distance from the source of such material we can not now manufacture as cheaply as other nations. For example, we can hardly hope to compete with Germany in the manufacture of potash salts on account of their ownership and proximity to the Stassfurt salt beds. Proximity to supply of raw material can, however, be counterbalanced to a certain extent by available power. In this we lead the world, as shown by statistics taken from foreign authorities.

Dr. Borchers, of Aachen, in an address before the Deutschen Elektrochemischen Gesellschaft, recently presented the following figures of available electrical power existing or projected by the countries named:

	By Water H. P.	Steam. H. P.	Gas. H. P.	Value of Possible Annual Product.
England	11,500	8,150	20	$2,270,000
Switzerland	38,950	----------	----------	3,153,163
France	110,140	1,300	----------	11,277,935
Germany	13,800	16,173	----------	13,786,550
United States	72,300	11,750	2,500	97,506,440

Zeits. für Elektrochem. 1899, 6 (3) 61.

No account, however, is taken of the "mental forces" of which Lunge said in his Hurter Memorial address: "This brain energy is surely just as valuable as other more tangible forms of energy."

We believe that any people may take up any form of industry, and by energetic application, master it. However, should it be granted that certain peoples are peculiarly fitted for selected industries, the United States is more fitted for meeting the demand for all forms of manufacturing than any other nation on the globe, for what are we, if not cosmopolitan?

Our reports invariably state that in exporting chemicals we are making less progress than in other industries. Our exports in chemicals, as dyes, drugs, etc., in 1889 amounted to $5,542,753; in 1898, $9,441,763. These include, respectively, as patent or proprietary medicines, $1,796,202, and $2,460,669. While our imports in chemicals for 1889 amounted to $39,754,672, and in 1898 $41,471,291.

We have thus made little headway in capturing our home demands, much less have we invaded the foreign markets. Emil Gautier has said that "All nations, including France, pay Germany tribute for the necessary and profitable products used by apothecaries." Germany by unceasing toil and the employment of numerous chemists has become the mistress of the world's chemical markets, supplying four-fifths of the total demand. A striking illustration of this is seen in the Badische Anilin und Soda Fabrik where 125 chemists, university trained men, work under the direction of Bernthsen. One-fifth of this corps of chemists attend to the routine analytical work of this one concern, while the remaining 100 prosecute researches along the lines of manufacture. The salaries of these chemists, excluding the chief, vary from $1,000 to $5,000 a year. The number of chemists residing in the three countries of which we have been speaking are roughly, Germany 10,000, England 8,000, and the United States 5,000.

While to be sure our chemists have as yet made no epoch-making generalization, no discovery of the first magnitude

has come from our laboratories, our position to-day in the metallurgical world as unquestioned leaders is due in large measure to the employment of efficient chemists. Appended is a list of our principal exports (manufactures). It will be noted that those showing the greatest increase within the past decade, namely, iron and steel, copper, zinc, fertilizers, vegetable oils and paper, are those which employ chemists, upon whose analyses everything bought and sold depends, and who guide every step of the process of manufacture.

Domestic Exports of Manufactures.	1888.	1898.
Iron and steel	$17,763,344	$70,406,885
Copper	3,812,798	32,180,872
Zinc	18,601	1,339,668
Fertilizers	1,255,028	4,359,834
Paper, and manufactures of	1,078,561	5,494,564
Oils, vegetable	381,990	1,843,011
Paraffin	2,168,247	6,030,292
Paints	492,709	1,079,518
Soap	815,864	1,390,603
Glass	881,628	1,211,084
Refined mineral oils	41,260,401	51,782,316

We have been prodigal with our enormous natural riches. It has been said that a German family could live off what an American family throws away. It is a striking antithesis that all our energetic business men have not earlier and more fully appreciated the value of a chemist like one portion of them whose business has increased with such wonderful rapidity.

The general government and states have shown their appreciation of the chemists as evidenced in the number of chemists employed in the various departments, as the treasury, patents, agriculture, experiment stations, customs houses, fertilizer-control stations, etc. Very few competent chemists have had to give up the profession through failure to secure good situations. To be sure they do not constitute a

wealthy class, but some are rich and few poor. As stated, many of our own chemists are foreign trained. The laboratories of our larger institutions now give similar training,and it is no longer necessary to go abroad to become thoroughly equipped as chemists or chemical engineers. The thing for us to do is to show more of the business men the need of, and the advantage in, having good chemists, and they will employ them. Driven by sharp competition, although hampered in the comprehension of the chemist's value by their own faulty education, financiers will employ them. We must teach them how the chemist can utilize their waste products, start new industries and improve older processes. It is hardly necessary to call attention even to the enormous wastes of the products of combustion in the manufacture of coke, production of cement from slag, for these matters are already taken up by the people whom we would interest in that direction. This has happened only within the last ten years, however, and is a good omen. The Germans have realized the danger of losing our import trade in chemicals, and to meet that loss are establishing their own factories in America for the preparation of the aniline dyes.

There are some matters of legislation the chemists need to look after, as well in their endeavors to develop the chemical industry, for instance, the necessity for having a less heavy tax on alcohol to be used for manufacturing purposes, assisting in the establishment of more State geological surveys whose work may show new pyrites deposits, sources of potassium salts or lithium. A very vital thing we must work for, and the most difficult to procure, on account of one's inability to show the immediate value of such to the ordinary legislator, is the proper equipment of laboratories for true scientific work. Pure and applied science can not be divorced. They are interdependent. Pure science puts aside empiricism and substitutes logical reasoning, while applied science

is an incentive to the former. They should go hand in hand. Where one prospers the other is sure to follow. It may be well here to call attention to a case in point showing their close relation. The determination of an atomic weight is about as abstract a piece of scientific work one can imagine. Yet Clarke's recent reference to the various values given to chromium is sufficient evidence of the practical value to which such information may be put. This is furthermore impressed upon us when we realize that immense values in money are dependent upon accurate analytical work, whose foundation is mass values. Hundreds of millions of dollars change hands annually through the say-so of analytical chemists, the "poorly paid slaves of commerce," as Martin puts it.

What we have had to say in regard to the improved condition of our laboratory facilities and trade conditions through the employment of chemists is unfortunately true only of those States constituting the northern and western portions of our Union. In the South, although we have made considerable progress recently, we are yet far behind.

We have had time to recover from the paralysis due to our violent dismemberment four decades ago. Our educational facilities are greatly improved through State and private aid, although the financial support accorded is by no means in just proportion to the deservedness of the cause. Our business enterprises have grown not in a temporary boombubble, that requires but further attenuation to burst and leave us a hapless wreck, but slowly and surely. Our manufactures are builded upon a firm foundation for our present conditions. These foundations must be broader and firmer in order to bear the weight of structures of loftier heights and the whirlwind of sharp competition that will and must come sooner or later. A means for accomplishing this is found in our remaining words.

Chemists have not been appreciated in the South. This statement is not based upon our individual impressions alone, but is substantiated by carefully gathered statistics. Of the graduates of our Southern institutions who specialized in chemistry within the last ten years 33 per cent secured positions as teachers of chemistry, usually with some other subject, as physics, geology, or biology, in conjunction; 67 per cent secured places in the industries, but half of these secured their places north of Virginia. Of all these men (200 in number), but 5 have had to give up chemistry on account of failure to secure a good position. The salaries paid these graduates ranged from $500 at the beginning to $4,000 per annum, the highest reported. The salaries will average for men out of college at most ten years (not a fair length of time to take) from twelve to fifteen hundred dollars a year. From what we can learn, this is quite as good, if not better, than young lawyers or physicians average in the same period.

The largest percentage of graduates employed in the South from any of the Northern institutions was 10 per cent, and the number ten. Statistics secured from the Northern and Northwestern Universities and Colleges, show that within the last ten years they have placed but five teachers of chemistry in the South, and but twenty chemists in the industries. One comparatively small Northern institution, in 1894, had fourteen graduates in chemistry, and placed them all in the North at good salaries. Many of the great Universities of the North reported that during this period of rapid forward strides of our nation they had not placed of all their graduates a single chemist in the Southern States.

As an illustration of the manner in which some of our largest business men look upon a chemist,and his services, the following two incidents may be related. Within the past three years a chemist was consulted by the owner of a large mill in regard to an accident that came nearing causing the

destruction of his factory. After a three-weeks' investigation of a difficult character, the cause was learned, a means to prevent the recurrence of the accident provided. The small fee of $50 was regarded as absolutely exorbitant. A company of capitalists desired to purchase a silver mine in Mexico. These men wanted an expert to visit the property and make a several weeks' thorough investigation, saying their decision to buy depended upon his report. A nice trip to Mexico was the compensation offered, while the lawyer accompanying the expert was to receive $1,000 for investigating the title of the land. These instances are easily multiplied.

What is the cause? While we must confess that part of it is at our—the chemist's—door, we are not altogether at fault. Dr. Phillips, a Southern man, in writing of our luxuriant self-confidence in mining gold in the South, says: "Owners * * * have not stopped to consider that it would pay to employ mill men at $5.00 a day, and save gold rather than $1.50 and $2.00 a day and lose it." *

Our educational system has been wrong. While we are ardent individualists, yet in America, and particularly in the South, we have sometimes carried the spirit of individuality too far. Instead of concentrating our educational interests into one immense engine, sectarian rivalry, jealousy of state, bucolic prejudice in legislative bodies, have separated our institutions of learning, to the eternal detriment of some phases of the whole. The harm done is keenly felt in the scientific branches of the various faculties. How much more effective, for example, would be the chemical work of one great laboratory located at any one of the institutions in this State with the endowment and present support and various faculties of these institutions working under one roof? The avoidance of unnecessary duplication of routine—elementary

*_Eng. and Mining Journal_, 63, 479.

routine—increased opportunities for research, variety of courses that could be offered, and more than all, the atmosphere of kindred spirits working in unison flash across the mind.

One hour of endeavor to remedy an ill is worth more than months of fruitless retrospection. We professors should drum the necessity for better equipment into the authorities until they provide it by some means or other to get rid of our nagging, if through no other motive. Then, we chemists, teachers and analytical chemists, should lose no opportunity in educating our business men, our manufacturers, to the proper appreciation of the value of good chemists to them in their business. It will be absolutely necessary for our mill men, for example, to learn the lesson through hard and bitter experience, if they do not pay heed to our warnings. Northern mills are invading our Southland. The Yankee Southerner is a new factor. They will, by these movements, overcome our present advantages of proximity to raw products and climatic conditions. With them chemists are not a luxury, for they show them how to utilize their waste products for profit, which will result in injury, if not extermination, of our enterprises unless we follow the same practice. It is the chemist and his work replacing rule of thumb methods that makes this possible, for the business acumen of our Northern brothers is no keener than our own. Our metallurgical producers have learned the lesson. Many of our fertilizer factors appreciate the value of a chemist, and are relying more upon them than their former empirical methods, but many make but spasmodic use of the chemists. Sugar refineries have found them indispensable.

Far be it from our purpose to appear faultfinding with the past and the efforts made by our instructors who labored not in vain. Let us younger men carry on the work, with even more vigor. We wish to urge this point, that the young men,

students, will come into our laboratories fast enough when the demand is made for them by the enterprises. Not for analysts, that is not our point, but for chemists. We know of numerous cases where mere boys have been taught to make a precipitation and filteration of certain things, and the manufacturer thought he had a chemist, and one at a very much less cost than a trained college mind. The absurd shortsightedness of such an employer is too obvious to be dwelt upon. We must, it seems, be occulists as well.

We produce in the United States over $100,000,000 worth of paper annually. Only the other day a consignment of cotton wood, enough to load thirty trains of twenty-five cars each, was shipped from Mississippi to the paper mills of the North. We can not recall a single paper factory of any size within the borders of our Southern States. It is the cotton-mill story over again. We ship the crude drugs North, and buy them back refined. We have the pine, needle and wood, that may be utilized. Look around at the thousands of tons of sawdust thrown away. But very recently the only copper smelter in the South was established at Norfolk. The opportunities are numerous. With the growth of our cities municipal governments must have advice as to the disposition of sewage, proper oversight of water supply. Citizens must have protection from adulterated foods and drugs. No purchaser of steel will accept a large consignment without chemical analyses to prove that it comes up to contract. No acids works will accept a thousand tons of pyrites, niter, or what not, without chemical analyses to prove that the requirements are met. Why, therefore, does a coal dealer or mill owner receive ten thousand tons of coal without a chemical analysis to prove that the product possesses the steam-raising value advertised? Why do our tobacco manufacturers accept ten tons of licorice mass without analyses to prove the content of desired glycyrrhizin? Or our grocers receive two thousand

barrels of flour without having analyses to prove the amount of wheat flour present? That is what they pay for. Our druggists and those who handle paints receive and sell ignorantly many gallons of linseed oil adulterated with from 10 to 25 per cent of cheaper mineral oils. It has been useless to mention these things, instances of which are numerous, to you who are familiar with such matters, but we would urge that you make it known more generally to the laity. Chemistry is a moral stimulant to business without a corresponding depressant effect.

This is no calamity cry. One has only to study the growth of chemistry and its influence during the past decade, not only in the United States in general, the South in particular, but our own State especially, to note the great improvement along the lines suggested. While we have much to be thankful for, we have more to strive for and look forward to.

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THE CONDITION, PROSPECTS, AND FUTURE EDUCATIONAL DEMANDS OF THE CHEMICAL INDUSTRIES.[1]

By Wm. McMurtrie.

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IT has been well said that chemistry is an offspring of the nineteenth century. The closing years of the eighteenth century had some glimpses of the wonders the new science had in store, but it remained for the workers of the first decade of the nineteenth to collaborate the results obtained by their immediate predecessors and develop the new truths which finally established the foundation of the glorious structure, which has now grown so great. During this period, human necessities were in every way augmented and particularly in France, claimed to be the fatherland of our science, human ingenuity was sorely taxed to meet these needs.

The struggle to find ways and means stimulated the energies and increased the zeal of the searchers after truth, and the utilitarian quest, as is always inevitable, brought forth results of interest and value above and beyond the actual needs, furnished data upon which are based the most important and fundamental laws of the science, and firmly established many of the most important of our industries. The labors of the chemists of the

[1] Presidential address delivered at the Chicago meeting of the American Chemical Society, December 27, 1900.

last decade of the closing century had cleared away the haze which surrounded and covered the truths already developed and opened the way for further promotion of the newly born science. Lavoisier had led by the introduction of systematic and accurate observation and record, to the crystallization of what had so far concentrated, and his associates, imbued with his spirit and inspired by his genius, were ready and willing to carry forward what he had so nobly begun.

And so the science was launched. How it has progressed during the century now closing has been told in many ways by many men and the history seems ever new. New laws and new truths found applications in the industries and increased the material wealth and the industries in turn furnished the material, the data, the incentive, for much of the additional investigation necessary to the development of the further laws.

The activity of the last decade of the last century has its counterpart in that of the century just closing. If the former century established the foundations, the closing century has furnished a superstructure worthy of the great minds who began the work. And whether we consider the later achievements from the side of abstract science or from that of the applications of the great laws to the material needs the glory is equally manifest and the wonder no less profound. Whether we consider argon and helium, neon, krypton, and xenon, and the beautiful researches which led to their discovery, polonium and radium, and their remarkable properties, the Roentgen reactions or the liquefied gases, and the attainment of the almost lowest limit of low temperatures, or the wonderful advances in illumination, the production of high temperatures in the electric furnace, the development of new compounds and forms of matter through the aid of these temperatures, the applications of high electric tensions to the production of new reactions, even those most familiar with them must feel the influence of the mighty strides and look into the future with enthusiastic hope.

The interest manifested in the new science in the old world was quickly extended to the new and it found most active lodgment here. Students and associates of Black in Scotland, Fothergill in England, and of the French chemists of the last quarter of the century in Paris, started the work and the names of Rush, Hutch-

inson, Woodhouse, McLean, Franklin, Rumford, Priestley, Silliman, Hare, Seybert, Norton, Dana, and others, will ever find affectionate memories in the minds of the chemists of America. What these men started has been actively developed by those who followed them, until to-day the science and its applications find more actual workers in our country than is to be found in any other country within the bounds of civilization.

The first half of the century had comparatively few men in the United States who could be classed as working chemists. Chemistry had, it is true, been taught in a way in many of the colleges. But systematic work, as we know it to-day in many of the institutions of learning, was practically unknown. Those who felt the special need of, and had a desire for, such instruction, were constrained to seek the facilities in other lands, until generous and at the same time practical men, such as Lawrence, Sheffield, Packer, Pardee, and Harrison, with enterprising eyes and prophetic vision, saw the advantages to be derived from the further development of the sciences and provided the means whereby well furnished laboratories could be opened up and facilities for the profound study of the science could be made possible. But the industrial needs of the country for more exact knowledge of the natural laws extended beyond private munificence and the national legislatures early recognized the importance of the better education of those who must manage the rapidly growing industries. The successful efforts of the late Senator Justin S. Morrill and his associates in securing the enactment of the law, which provided for the establishment in each state of an institution for study of agriculture and the mechanic arts, is well known and will always be gratefully remembered. No less important were the efforts of the late Mr. Hatch, of Missouri, who labored so earnestly and eventually so successfully for the establishment of the state agricultural experiment stations. There can be no question that nothing has done more for the promotion of the science of chemistry and its applications than the acts of these great captains of industry and legislation. We shall not forget further the wonderful benefactions of Johns Hopkins, Clark, Case, Rose, Rockefeller, Stanford, Schermerhorn, Havemeyer, Fayerweather, Carnegie, and others, who have furnished, through splendid

munificence, the magnificent facilities not only for instruction in the science but for abstract research as well.

The science received splendid impulse and inspiration in the meeting at the grave of Priestley, in 1874. It brought the chemists of the country, then comparatively few in number, together and established the bond of good fellowship and scientific sympathy, always so necessary to true progress. The most important outcome of this most important gathering was the organization of our own Society. In his address delivered at that meeting, Professor Benjamin Silliman named 85 chemists who had contributed to the advancement of the science in the United States at that time.

In 1876, the American Chemical Society was organized and during the year enrolled 230 members, of whom 190 were professional chemists. The impulse given in Northumberland was effective, the example of a few devoted and public-spirited men was followed, and though a period of almost fifteen years was requisite to the ultimate firm establishment of the work of the organization and the integrity of the Society itself, the great aims of its founders to secure the harmonious and thorough organization of all the chemists of the country finally prevailed. The Society has continued to increase in membership and influence, until at the present time thirteen local sections have been established in various parts of the country all actively working, and at least six of them holding monthly meetings during all but the summer months, for such scientific intercourse and discussion as cannot fail to be fruitful in the promotion of the science. The roll of membership now contains about 1750 names and while this represents but a small proportion of the working chemists of the country, its growth henceforward must be rapid and the hope of the founders fairly realized.

The Journal covers, annually, nearly 1000 pages of matter fairly representative of the work of American chemists and it has become necessary because of increased demands for it to publish an edition of 2700 copies. Its pages are open to communications on all subjects relating to chemistry and its applications, and it is the hope and expectation that the valuable Review of American Chemical Research may be accompanied in the near future by abstracts of papers published in the foreign journals, thus furnish-

ing to all our members information regarding the world's work in chemical science and practice.

The progress made in the applications of chemistry in our country can properly and fully be told only in the results of the census now in progress and in hands which promise results of higher value than have ever before been obtained in such work in this country. We may congratulate ourselves that it has been entrusted to our past president, Dr. C. E. Munroe, whose tastes and training have so admirably fitted him for the delicate and difficult task submitted to him. But we have in the figures prepared by the Bureau of Statistics of the United States Treasury most significant data regarding the progress made during this closing decade of the closing century. From this source we learn that of products classified as chemicals, drugs, and medicines, we imported during the year ending June 30, 1890, to the value of $41,601,978, while for the year ending June 30, 1900 this value had become $52,931,055. Most of the materials represented in these figures entered into consumption in industries, based wholly or in part upon the applications of chemistry. We cannot enter into the details of these statistics, but we may consider with interest and profit a few figures relating to some well-known industries and which are instructive in this connection, as showing the variations which have occurred during the decade.

CHEMICALS IMPORTED IN 1890 AND 1900 RESPECTIVELY:

	1890.	1900.
Caustic soda	$1,470,335	$ 158,793
Soda ash	3,493,288	665,104
Potash, chlorate of	238,840	102,337
Soda, chlorate of	......	93,076
Lime, chloride of	1,385,080	1,461,858
Glycerine	928,935	2,138,670
Alizarine colors	358,882	771,336
Coal-tar colors and dyes	1,787,553	4,792,103
Other coal-tar products	....	397,780
Milk, sugar of	46,510	399
Glass	7,411,343	4,038,753

The figures indicate enormous growth of the alkali industry in the United States during the decade and show that in this branch of industry we are entirely independent as regards supplies of foreign producers. The figures for glycerine show the possibilities

of expansion of another industry, while the almost astounding growth of the importations of alizarine and coal-tar products and dyes indicate the necessity for the further development and utilization of our own sources of crude materials of like character and the extension of that already begun. The rapid growth of the establishment of the by-product coke ovens reveals great possibilities in this direction and it must be disappointing if the characteristic enterprise fails to take advantage of these possibilities.

If the importations of chemical products are interesting and indicate great activity and growth in the industry, the figures for the exportation of similar products are even more significant. We submit figures for the years ending June 30, 1890 and June 30, 1900 respectively, including in the table some data for 1876, the year of the organization of our Society. To have predicted these results in the beginning of the quarter century would have invited incredulity, but so also would predictions regarding the advances to be made in other lines of human industry. The figures are worthy of careful study.

Values of Exports of Domestic Products of the Chemical Industries for the Years Ending June 30, 1876, June 30, 1890, and June 30, 1900 Respectively:

	1876.	1890.	1900.
Bark and extracts for tanning	$ 223,276	$ 263,754	$ 376,742
Beeswax	......	17,927	91,913
Blacking	81,401	238,391	880,049
Candles	229,311	143,073	191,687
Celluloid	......	39,004	174,264
Acids	50,300	98,084	146,722
Ashes, pot and pearl	75,597	26,211	49,566
Copper, sulphate of	......	......	2,120,745
Dyes and dyestuffs	......	717,128	498,056
Lime, acetate of	......	......	776,413
Other chemicals not separately enumerated	2,471,195	2,840,931	5,536,716
Cider	......	193,283	64,283
Coke	......	53,586	1,233,921
Coffee and cocoa, ground and prepared, and chocolate	......	93,735	228,241
Earthen-, stone-, and chinaware	......	175,477	575,823
Fertilizers	922,221	1,618,681	7,218,224
Glass and glassware	646,954	882,677	1,933,201
Glucose or grape-sugar	......	855,176	3,600,139
Glue	5,798	88,484	225,844

	1876.	1890.	1900.
Grease, grease scraps, and soap stock	......	1,506,819	2,944,322
Gunpowder and other explosives...	67,887	868,728	1,888,741
India rubber, gutta percha, and manufactures of............	88,816	1,090,367	2,364,157
Ink, printers' and other..........	......	147,057	259,776
Leather	......	11,175,141	15,363,584
Lime } Cement }	77,568	134,994	{ 85,854 { 163,162
Malt	......	60,412	215,198
Malt liquors	42,664	654,408	2,137,527
Matches.........................	153,680	52,284	95,316
Naval stores	9,799,923	7,444,446	12,474,194
Oil cake and oil cake meal	.....	7,999,926	16,757,519
Oils, animal	1,975,972	1,686,643	718,997
" mineral, crude...............	2,220,268	6,744,235	7,364,162
" " refined or manufactured......................	30,502,312	51,403,089	68,246,949
" vegetable, corn	......	......	1,351,867
" " cotton-seed	146,135	5,291,178	14,127,538
" " linseed	23,770	55,036	54,148
" volatile or essential	248,270	223,435	256,597
" all other	......	102,792	554,295
Paints, pigments, and colors.......	179,882	578,103	1,902,958
Paper and manufactures of	795,176	1,226,686	6,215,559
Paraffin and paraffin wax	......	2,408,709	8,602,723
Perfumery and cosmetics..........	375,011	430,151	*358,589
Photographic materials	......	3,891	1,164,465
Plaster	......	5,153	35,017
Lard	22,429,485	33,455,520	41,939,157
Lard compound and substitutes....	......	......	1,474,464
Oleo and oleomargarine	......	6,773,522	10,920,400
Butter...........................	1,109,496	4,187,489	3,142,378
Cheese	12,270,083	8,591,042	4,939,255
Milk	......	303,325	1,133,296
Salt............................	18,378	29,073	55,833
Soap...........................	684,739	1,109,017	1,773,921
Spermaceti......................	35,915	116,757	67,125
Spirits, wood...................	......	......	320,306
" grain (neutral and cologne)	......	178,257	59,277
" brandy	......	......	83,698
" rum	......	663,039	903,808
" whiskey, bourbon..........	......	498,250	764,860
" " rye	......	137,029	121,241
" all other	......	165,535	24,921
Starch	524,596	378,115	2,604,362

* 1899.

	1876.	1890.	1900.
Sugar and molasses	6,745,771	3,029,413	3,697,366
Tallow	6,734,378	5,242,158	4,398,204
Varnish	54,906	206,483	620,059
Vinegar	6,133	10,520	12,583
Wine	33,483	270,930	62,592
Wood pulp	......	2,245	458,463
Yeast	......	.....	36,061
	102,054,750	174,803,105	264,501,771

The figures show grand totals as follows :

For the year 1876	$102,054,750
" " " 1890	174,803,105
" " " 1900	264,501,771

In the decennial period just closing, the increase in the value of the exports of products of domestic manufacture was therefore about the same as during the preceding fourteen years, and during the quarter century the growth has been 260 per cent. The growth has been persistent and steady and indicates what may be expected in the immediate future as well as what is now the condition of development of our chemical industries. This latter condition becomes more manifest when we consider that the products exported constitute but a small proportion of the production, and we may in some degree at least anticipate the results which must be obtained in the pending census investigation.

As further illustration of the growth of the chemical industries, we may call attention to the condition of the coke industry in the United States in 1880 and 1898, respectively, as illustrated in the following table :

	1880.	1898.
Establishments	186	342
Ovens { built	12,372	48,447
Ovens { building	1,159	1,048
Coal used, net tons	5,237,471	25,249,570
Coke produced, net tons	3,338,300	16,047,299
Total value of coke at ovens	$6,631,267	$25,586,699
Value of coke at ovens, per net ton	$1.99	$1.594
Yield of coal in coke, per cent	63.0	63.6

If we consider that in the recovery ovens, which are fast taking the places of the older and less rational types, this coal should yield 3.38 per cent. of tar, 0.34 per cent. its weight of ammonia and 8.17 per cent. of gas liquor, all of them bases of most important chemical industries, the figures are significant.

Equally interesting must be the information to be furnished regarding the capital represented in the chemical industries in this country. At the present time, we are able to judge of this to a minor extent from the reported capitalization of the recently organized companies constituting combinations of preexisting companies. It is true that in these cases the capital represents in a very considerable measure what is known as good will, franchises, etc., but it nevertheless represents earning power and the average market value corresponds very closely with par value. Taking only those organizations devoted to the chemical manufactures exclusive of the gas and metallurgical and explosive industries, we find that the capitalization as reported in the stock lists amounts to the enormous value of about $1,500,000,000 and this takes no account of many of the incorporated industries not specially reported, nor the industries not incorporated and yet active. It does not include the recently developed electrolytic industries, in which the cash capital actually invested, as we learn from competent authority, amounts to more than $1,500,000. The newly established by-product coke industry is rapidly developing and is absorbing capital with wonderful rapidity, while the comparatively new beet-root sugar industry has already developed to such an extent as to involve capitalization of nearly $100,000,000 and to develop the establishment of manufacturing plants of magnitude beyond the imagination of foreign manufacturers in the same line a few years ago. Yet this is a general characteristic of the modern chemical industries of the United States and it is interesting to note that much of the development has been effected empirically and by men comparatively little versed in the principles and laws of the science upon which they are based. The industries have had the aid of but few educated chemists. Happily this condition is rapidly changing. Rational work is coming to be recognized and the demand for well-trained chemists is increasing. We cannot yet boast with the Germans that single works employ more than 100 thoroughly educated chemists, yet inquiry shows that many of the important works have corps of chemists numbering from 10 to 50, while very many more have smaller numbers. The same inquiry affords some clue to the number of chemists actually at work in this country. If we compare the list of members of the American

Chemical Society, we find that more than two-thirds are engaged in technical work. Furthermore, of the few chemists reported in the inquiry just referred to, scarcely one-third are members of the Society. A fair estimate based upon such data leads to the conclusion that more than 5,000 chemists are actually at work in the United States, and that 80 per cent. of these are connected with the industries. A study of the lists of the graduates of the educational institutions leads to similar conclusions. Fischer reported as the result of special inquiry made three years ago that in Germany 4,000 graduate chemists were employed in the industries and about 200 in teaching and special investigations.

So then we find that the chemical industries of the United States are growing with enormous rapidity; that they are being concentrated into fewer but larger works; that operations and reactions are being carried out with a magnitude which the earlier chemists would never have predicted; that new methods are being followed; new principles applied, greater accuracy of results demanded both as to quality and yield of the products; that the products now issue from the works in lots of tons at a time of a higher degree of purity and with a greater economy than was possible but a few years ago with lots of a few hundred pounds. For instance, the great sugar refineries each yield from 1,000,000 to 2,000,000 pounds daily of a product, the purity of which may be considered absolute. The modern beet-sugar works have in some cases capacity for treatment of from 1,000 to 3,000 tons of roots daily and consequently the purification of almost an equal quantity of juice.

And if so great advance has been made during the closing quarter century and even decade, what shall we say of the possibilities of the future? What is to be the magnitude of the chemical industries of the United States? What shall be the character of the products issuing from them? What will they require of the men who must direct and control them? That is to say, what will be the educational requirements of the American chemical industries of the almost immediate future? These questions are not new to our own country and their importance has forced itself with powerful intensity upon those engaged in the chemical industries in the old world; it has been the subject of most earnest discussion, particularly in Germany and England, during

the past five years at least. Nor has it been in all respects satisfactorily answered. Even within this closing month of the closing century the cable has flashed news of the complaint on the part of the leading statesmen of England that the training of technologists in that country is inadequate to the development necessary to meet foreign competition and at almost the same time brings news of the inauguration of new institutions for technical education. And in Germany also, the home and starting-point of many of the great industries, the demands upon the educational institutions for the better training of technologists are being pressed from every side. It is natural to believe that the time is not far distant when we too shall be called upon to make and meet similar demands. It may be pardonable therefore to discuss briefly what these requirements are likely to be.

First of all, experience shows that those who financially control the great industries, fully appreciate the need of improvement in both processes and products, are particularly apt in propounding hard questions in connection therewith and always expect that these questions shall be answered quickly and with the utmost accuracy. Young men who early come to a realization of this fact and prepare themselves by broad and thorough education to meet it are those who will succeed in the industries and ultimately have a controlling influence in their management. And what is to be said here on this subject is directed as much to the students as to those who instruct, for it is not difficult to understand the restrictions placed upon teachers by the students themselves, in the struggle to arrange work leading to the training, which many realize to be absolutely essential to meet the requirements of the near future.

For it is beyond question that the most thoroughly educated man is sure to best meet these requirements and become the leader in the industrial struggle of the near future. Dr. Duisberg, the director of the great color works at Elberfeld, Germany, rightly fixed the standard when he said that "above all a general comprehensive education is required. We must have in the industries persevering, energetic men with broad views." And Dr. Chittenden was right when he said: "Given a young man of broad knowledge and a thorough conception of the principal laws of physics, mechanics, hydraulics, etc., and he will soon adjust him-

self to the environment of professional work, and eventually rise to a plane far beyond that of the man whose training has been purely technical,'' and concluding his paper he says: ''The rapid development of the sciences and their manifold industrial applications have opened up avenues for new ventures of great magnitude and there is an increasing demand for young men of broad scientific knowledge and training. He who wishes for the fullest possible measure of success must prepare himself thoroughly for his life work and he can do this in no better way than by acquiring a broad and liberal education.''

This important requisite to success could not be better described. Careful general training is conducive to the best thought and the best expression of the results of inquiry. And it is too frequently true that technical men are especially lacking in this particular. Too early specialization must tend to narrowness of view, and therefore to limited influence. The general culture work of the preparatory schools or of the colleges will always be profitable, whether as preparatory to a specialty or an auxiliary to its prosecution. These principles will apply to all technologists whether they are chemists or not.

But what shall be the character of the special training of the technical chemist? First of all, we must admit, that this must cover thoroughly and profoundly a study of the science of *chemistry*. Dr. Fittig declares: ''Our problem is to study the science as such; to lead the student into the methods of strictly scientific investigation, to put him into position to solve pure scientific problems entirely independent of the question, whether he shall devote his powers to the service of the science itself or apply it to practical questions.'' He claims that many students take up the study without the scientific instinct. And Erlenmeyer says: ''A true scientific training should produce ability and susceptibility for all and every use. With a knowledge of the principles and laws of the science, their use becomes easy, they proceed independently.'' Foerster, discussing the needs of the electrochemists, says: ''But above all be particular to secure fundamental training in the entire field of chemistry, thus utilizing the principle insisted upon by Liebig, that the best training for any specialty rests upon the broadest foundation in the whole of scientific chemistry.'' Dr. Duisberg says further: ''In technical chem-

istry the sharp eye of the scientifically trained man is wanted in order to recognize the individual developments of the reactions in progress, which can be seen only through the accompanying indications.'' And Richard Meyer truthfully declared: ''If our technologists did not properly appreciate the service rendered by men trained in the spirit of Liebig, chemical investigation would miss the stately crowd of auxiliary powers, without which the heights from which we may now look proudly backward and hopefully forward, could never have been attained.'' And W. H. Perkin says that ''technical education will be of small value unless it is carried out on a very broad and scientific basis.''

These views of the leaders in the science of chemistry must find an echo in the mind of every man who has had experience in the industries. In no department of human activity is a thorough knowledge of the fundamental laws so needful, nor can the knowledge of any law be safely neglected if successful work is to prevail. For all the laws apply all the time and few cases will arise in which the more important can be avoided. To suppose that the industries can be carried on in the face of severe competition without such knowledge is to invite failure in every case. Empiricism may succeed in times of plenty, but adversity breeds rationalism and fosters the support it can bring. So then we may make no distinction between inorganic and organic chemistry, analytic and physical chemistry, for each one has its place in the world's work, and no one can predict when any one of these branches will be called upon to render material aid.

But whatever may be the department of chemical study the relation of the science to physics will be keenly felt, and the dependence of each upon mathematics as the true foundation will become manifest. For this latter science is just as powerful an aid in the determination of the motions of the atom and molecule in matter as those of the worlds and constellations in space. And if it cannot be neglected in astronomy, no more can it in chemistry and physics. Indeed, it illustrates the unity of all the sciences, even as it does the correlation of all the forces. Dr. Lorenz set forth the need of all chemists in this particular when he said: ''Modern electrochemistry is an exact science, and its principles, and a knowledge of it rests upon a foundation of mathematics. It is in every way desirable that every electro-

chemist shall be trained in the higher mathematics, and be thoroughly able to utilize both differential and integral calculus." He particularly recommends as a preparation therefor the "Introduction to the Mathematical Treatment of the Sciences" of Nernst and Schönflies and says: "If the student have an intensive rather than extensive training in mathematics, he may be thrown into the sea of natural science and left to swim." So also Foerster discussing the character of the instruction in electrochemistry in the technical high school, while insisting upon "thorough fundamental work in inorganic and organic chemistry, physics and physical chemistry" does not fail to include in his plan of work "the principles of higher mathematics." Dr. Koerner, discussing the importance of physical chemistry to the industries, says: "It is most characteristic of it (physical chemistry) that it utilizes the most powerful of all natural aids to scientific investigation, the higher mathematics." And in the curricula of the technical high schools in Germany we find almost without exception that in the course of chemistry, as well as in engineering, the higher mathematics is taken up and completed before the end of the first year, if not before the end of the first semester. It thus becomes the ground-work of and preparatory to, all the important work, which in those great institutions must follow it.

And finally, the technical chemist of the near future must be trained in the principles and practices of engineering, trained to make and operate the mechanical means for carrying out effectively the chemical reactions of the industries in a large way. For after all these reactions differ only in degree from those of the research and preparation laboratories, and if in the latter the students must be trained in making and assembling the forms of apparatus for use in the various operations of pulverizing, separating, roasting and incineration, solution, precipitation, separation of solids and liquids, washing, drying, and care of precipitates and crystals, the production and control of heat, the transfer of solids and liquids, the production and application of vacuum, evaporation and distillation, the conditions of crystallization, etc., in the small way in the laboratories, he must be taught to apply all these and more, in the large way in the works. Indeed, the only difference between the two may be comprised in the terms microchemistry and macrochemistry ; chemistry and the opera-

tions belonging to chemistry carried on in a small way with limited or small quantities or volumes ; handling solids and liquids in quantities of a few grams or a few cubic centimeters or liters on the one hand, or of tons of solids and thousands of gallons of liquid on the other. How, for instance, would the chemist, untrained in the principles of engineering, proceed in handling materials in quantities involving several tons of solid matters and 30,000 to 50,000 gallons of liquid in a single charge, a requirement not uncommon in the modern industries and sure to be more common in the future industry. In his day, perhaps, the great Liebig was right, and Wöhler was right, and Fittig, not far wrong, when they maintained that with a thorough knowledge of the principles and laws of chemistry, all else in the industry involving their application would be easy. It is possible that the genius of the young operator would come to his aid and enable him ultimately to devise means to meet his ends, but time and labor must be saved by training in the methods, whereby such means may be established and a knowledge of means already at hand acquired. The authoress of a late popular work of fiction was right when she said "untrained genius is a terrible waste of power," and though it may not be as applicable here as in an earlier paragraph, she was also right when she said in the same connection, "So many persons think that if they have a spark of genius, they can do without culture ; while really it is because they have a spark of genius that they ought to be and are worthy to be cultivated to the highest point." And this applies to the chemists who must operate in a large way and with large masses of matter, either solid or liquid.

In a discussion of this subject in England, where perhaps more than elsewhere in the world the need of engineering capacity on the part of chemists has been most keenly felt, and where on the other hand engineering capacity embodied in such men as Mond, Bell, Muspratt, Weldon, Perkin, and Chance, has brought forth such splendid results, Ivan Levinstein, himself, a leader in the industry, said : "It must also be palpable that a chemist intended for industrial work, who, along with sound training in chemistry, has also acquired a fair knowledge of chemical engineering, must be better fitted for his work than the man who is only practically acquainted with the handling of china basins, phials, or a Liebig's

condenser. And in the same discussion Watson Smith endorsed "what had been said as to the importance of teaching the scientific principles involved in the special construction of apparatus and plant for chemical processes on a large scale."

Dr. Ost, whose connection both with the industries and teaching, has been so intimate, says: "Liebig, who had for long years taught technical chemistry in Giessen and, as none other, had promoted the applications of chemistry, could say, in 1840, 'I know many (those trained in pure science only) who now stand at the head of soda, sulphuric acid, sugar and cyanide works, dyeing and other industries, and without ever having had previously to do with them, were completely entrusted with works' processes within the first half hour, and in the next brought forth a number of most important improvements.' Sixty years ago, this judgment characteristic of the time, this enthusiastic declaration of Liebig, would constitute a dogma, but it is no longer tenable. The chemist graduated from the technical high school is no longer in position to begin his factory experience with introduction of improvements." This, Ost says, is because of the better and more perfect organization of modern works. And Dr. Lorenz, of the Zurich Polytechnicum, says: "The electrochemist should not be graduated until he has been taught how to use modern methods in very large apparatus. We find in electrochemistry a wide difference between the theory and the facts. In the laboratory, current yield and greatest economy of electrical energy are often the principal considerations, but in technology corrosion of electrodes or diaphragms is much more expensive than any variation of energy." What an important illustration of a special study of materials of engineering in the preparation for the chemical industry! And what a sensation of sympathy this must arouse in all those who have had to do with the handling of corrosive materials in the very large quantities and volumes, which modern methods involve! How often it happens that success of an important operation is delayed and even made impracticable because of want of knowledge of suitable resistant material for construction of containing vessels or apparatus. Probably the most important contribution to this subject is that of Mr. Beilby. In his address he says: "I have rarely seen the chemistry of a process lagging behind the engineering; most frequently it is the

other way. The chemical reactions involved in the ammonia soda process are simple and easily understood, but it required the genius and practical skill of men like Solvay and Mond to devise apparatus which could establish the manufacture on its present secure basis. What are the elements of which the skill is made up? The scientific basis must be a thorough knowledge of the principles of chemistry, physics, dynamics, and mechanics, and added to this there must be a practical acquaintance with the materials of construction and the methods by which they are worked into structures. The designing and construction of apparatus for chemical works is a distinct branch of applied science. It is in this that special skill is required, for works' operations are not simply laboratory operations. The ideal chemical engineer should be in thorough sympathy with the modes of thought and with the methods of working of both the chemist and the engineer; just as the professor of engineering teaches how to apply the laws of statics, dynamics, and kinematics to the design of structures or machines, so should the professor of chemical engineering trace the applications of the laws of chemistry and physics and dynamics in the problems which occur in designing chemical apparatus for works. I am quite satisfied that in the present state of popular opinion the position and work of the technical chemist will not be properly recognized, unless he can associate himself, by his training and practice with the engineering side of his calling." Prof. Meldola says: "The sooner a chemist is made to realize the enormous practical difference between a laboratory and a factory process, the better it will be for him."

Prof. J. A. Reynolds, Director of the Municipal Technical Schools of Manchester, England, says: "English chemists are not engineers and English engineers are not chemists, and hence the enormous difficulty which arises in the endeavor to bring to successful commercial results the fruits of laboratory research." While Mr. David Howard considers that "the influence of mass action, the question of so many pounds of coal per horse power hour, and other like things, cannot be dealt with on a small scale, but are all important on a larger scale. We want chemical engineers who can make new roads in chemistry, as mechanical engineers do in railways."

It is also important to consider the course of study proposed by Mr. Beilby in his paper for prospective industrial chemists. His large experience in the chemical industry gives him power to speak with authority, and young men who look forward to a successful career in the industry, will do well to give it most careful consideration. And even more important, perhaps, are the courses of instruction carried out in the West of Scotland Technical College and in the Municipal Technical School in Manchester, England, and published in the Journal of the Society of Chemical Industry during 1899. Students who have had the advantage of these courses must be better fitted than those who have not been similarly favored. Yet we must believe that the courses laid out in the technical high schools of Germany and, we are proud to say, in some of the schools of technology in our own country, are in some respects better. Yet a combination of the two courses might be made with profit to both classes of institution. It is important that the works' chemists should be trained in the construction of the special forms of apparatus he needs to use, but they should be accompanied or preceded by the principles and practice of mechanical engineering. The most practical courses, perhaps, are those laid down in many of our own educational institutions for instruction in mining engineering and metallurgy, in which chemistry of the operations is considered in connection with the mechanical details of its applications, and we have advised students desiring to prepare for the chemical industries to pursue these courses in the best institutions first, and to follow them with a year or more of exclusive study of chemistry both pure and applied. If it were possible to add to the courses of chemistry as much of engineering, civil, mechanical and architectural, as is found in some of the metallurgical courses, the ideal would be more nearly met. But we can fully sympathize with those teachers who find the time available too limited for such a combination, and appreciate the fact that either the student must come to the professional school with better preliminary training in the preparatory subjects, or the courses must be extended beyond the usually provided four years' work. In any case, if a course of engineering could be carried side by side, and simultaneously with the course of chemistry, the needs of the prospective technical chemist would be

most fully met, and the requirements of the future chemical industry most nearly fulfilled. In some of our institutions in which all studies are practically optional, such a course might be arranged and profitably followed, and notwithstanding the longer time which might be involved in its completion, the graduate from it would issue with brighter and better prospects of success in his profession than one less broadly trained. And in the selection of the subjects for such a course, the plans of study laid down in the technical high schools of Germany, in the technical schools of England, and of our own country, may be profitably followed.

In 1897, we expressed the view which seems thoroughly applicable now and which will perhaps bear repetition here. We said: "It seems therefore that the demand of the present time, and of the immediate future can be met only by broadly educated men: by men who have been trained, not only in chemistry itself, but in the great principles of physics as well. A good technical chemist must be first of all a thoroughly educated chemist; after that, to attain the highest success in this country, he must be educated in the principles of engineering; the productions and applications of heat; the productions and applications of electricity; the transmission of power, the movement of liquids; in general, the means whereby the reactions of chemistry may be carried out in a large way. We need, therefore, chemical engineers and these in the nature of the requirements must be broadly and thoroughly educated men. While they must be trained in the work of the research laboratories, which are being organized in connection with many of the great industries, they must likewise be prepared to put into practical operation in a large way the results of the researches they have been called upon to make."

These truths have not changed, and if these conditions of education and training are fully met, the progress of our chemical industries must be greatly augmented, the science, must, by reaction, be actively advanced, and following the experience of our German confrères in the words of Meyer, we may look hopefully forward and in the near future proudly backward, to accomplishments greater than the world has ever known.

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CHEMICAL POSITIONS IN THE GOVERNMENT SERVICE[1]

WHEN we enter the profession of chemistry our chief interest is centered on the conditions that obtain in the various fields of chemical activity. In the case of those who retain their youth by contact with student life, that interest does not lessen.

Frequent inquiries covering a broad scope are made by students and recent graduates in chemistry, and teachers, to whom they naturally turn for advice, are constantly asking for material that will enable them to supply this information. Inquiries made at the Department of Agriculture regarding opportunities for chemical work are mainly from students who are nearing the completion of their college course, or from teachers who are directing the studies of others. Often the inquiry relates to the character of work which the student should undertake in order to fit himself for a position in the department. Unfortunately the information is rarely sought with a view to increasing the equipment of men who have received broad fundamental training. The purpose is usually to substitute for a portion of a regular course in chemistry, some special study that will afford a temporary advantage.

I offer these inquiries as my apology for discussing in a few minutes a subject

[1] Address before Section C of the American Association for the Advancement of Science, Chicago, January 2, 1908.

that would require a volume for its adequate treatment. It is my purpose to discuss very briefly the nature of the work done in those laboratories of the various departments of the federal government to which appointments are made with some frequency. I shall consider the subject only from the standpoint of the opportunities of the chemist seeking a position and shall not include those laboratories to which appointments are rarely made.

In 1885 this subject was discussed by Professor F. W. Clarke in his address as retiring president of the Chemical Society of Washington—now the Washington Section of the American Chemical Society.[2] The following quotation from his address is of much historic interest:

My first visit to Washington was in the autumn of 1873. At that time chemistry had gained but a precarious foothold in the public work. In the agricultural department, one chemist, McMurtrie, sometimes with and often without an assistant, occupied a small laboratory, and carried forward his investigations with very slender resources. At the Smithsonian Institution, Dr. Endlich, then in charge of the mineral collections, attended to general chemistry routine and made occasional assays. Then, as now, the speculative constituent tormented his member of congress and the institution with ores taken from granite bowlders; with fossils to be assayed for silver or tin; with iron pyrites rich in imaginary gold, or with alleged coal which proved to be nothing but black tourmaline. With such trivialities the time of the chemist was often frittered away, to the detriment of science and the benefit of nobody. In a basement room of the Smithsonian, dimly lighted and badly ventilated, Dr. Loew, with few reagents or appliances, made analyses of rocks and ores for the Wheeler Survey. At the Army Medical Museum, Doctors Craig and Mew examined drugs for the War Department. The Patent Office, of

[2] Bull. 1, Chemical Society of Washington.

course, employed a staff of chemists, but they had no laboratory, and their functions were critical rather than productive. In addition, the government had just started a laboratory connected with the Custom House at New York, and maintained another at Brooklyn for the purposes of the Navy. At West Point and Annapolis, chemistry was taught as an incidental study, but not by laboratory methods; and at Newport one or two chemists were engaged in the torpedo service.

Professor Clarke then gave a brief account of the progress that had been made in the twelve years following the date mentioned.

At the present time, of the nine departments, only three have no chemical laboratories—the Department of State, the Department of Justice, and the Post-Office Department.

TREASURY DEPARTMENT

The laboratory of the supervising architect's office is charged with the examination of metals, alloys, cements and miscellaneous structural materials. Its work is largely of a routine nature resembling in a general way that of a railroad testing laboratory.

The division of chemistry of the Bureau of Internal Revenue is charged with the analysis of all samples submitted under internal revenue laws. These include the determination of alcohol in distilled beverages, the examination of remedies containing alcohol to determine whether their medicinal principles are sufficient to exempt them from internal revenue tax, the examination of oleomargarine and adulterated butter and of such samples of mixed flour and filled cheese as are taken in connection with the laws regarding the taxation of those products. The laboratory

also examines supplies furnished other branches of the department under contract and supervises the work of subordinate laboratories at collectors' or agents' offices.

The scientific work of the Public Health and Marine Hospital Service is concentrated in the hygienic laboratory. The chemical division of this laboratory was organized in 1905. Its principal object is to cooperate with the other divisions of the laboratory in the solution of problems pertaining to the public health, and to undertake such routine chemical work as may be required by the United States Public Health and Marine Hospital Service at large.

As illustrative of the scope of the laboratory may be mentioned the chemical study of the water from the several sources used for drinking purposes in the District of Columbia; the examination of drugs and of pathological specimens, such as urine, gastric contents, etc., and a number of biochemical studies particularly on subjects related to experimental medicine and pathology.

Chemical laboratories are maintained in connection with the offices of the United States Customs Appraisers at the ports of New York, Boston, Philadelphia, New Orleans, Chicago and San Francisco. With the exception of that at New York, the chief work of these laboratories is the polarization of sugar. At the present time a laboratory is also maintained at Kansas City for the assay of imported ores. Approximately, seventy per cent. of the importations of the entire country are entered at New York, and in addition to the analyses of such goods, many of the

chemical problems of other ports are referred to the New York laboratory. Again, many shipments of exported goods, manufactured of imported materials under drawback regulations are examined.

The work of a customs laboratory covers a very wide range and includes all imported products in the classification and valuation of which the laboratory can assist.[3] The examination required is usually superficial, frequently but a single determination being necessary. It is apparent that the work of such a laboratory is essentially routine, but that new problems requiring originality and resource must frequently arise.

NAVY

The Navy Department maintains laboratories at the Washington, New York, Boston, Norfolk and Mare Island Navy Yards, at the Newport Torpedo Station and the Naval Proving Ground at Indian Head, Maryland. At the Navy Yard laboratories a wide range of products is examined including steel, iron, all kinds of alloys entering into the construction of guns and carriages, and supplies needed in machine shops and on the boats of the Navy. These supplies include lubricating and other oils, coke and coal, rubber goods for different purposes, paints, cements and other building materials, water and office supplies.

INTERIOR DEPARTMENT

The chemical laboratory of the Geological Survey examines rocks, minerals, clays, ores, waters, coal, etc., for the purpose of assisting in the geological problems

[3] Moore, *Jour. Soc. Chem. Ind.*, 1900, 19, 323–4.

of the survey and to determine the extent of the diffusion of the elements in nature. In this laboratory many important researches of quite varied character are conducted.

The technical branch of the survey also maintains laboratories, especially at Pittsburg, for the examination of coal and structural materials.

The water supply branch of the survey maintains a laboratory for the investigation of waters and has the cooperation of chemists at a number of points in the United States. Their work is largely the analysis of river waters in connection with irrigation problems, sanitary problems and the measurement of the amount of material removed from the soil by streams.

DEPARTMENT OF AGRICULTURE

Among the investigations now being conducted by the Bureau of Chemistry of the Department of Agriculture, the following may be mentioned: The study of the composition, character, and methods of manufacture and preservation of food, both from an economic standpoint and to determine their influence upon nutrition and health; the inspection in connection with the enforcement of the federal food and drugs act, of foods and drugs sold in interstate commerce and in the District of Columbia and the territories; the study of the influence of environment upon the composition of agricultural products; the study of conditions relating to the several saccharine products such as syrup, molasses, sugar and honey; the chemical questions relating to the dairy industry; the effect of trade wastes on forests and agri-

cultural products as, for instance, the effect of smelter fumes on vegetation and animals; the influence of chemical preservatives and colors on nutrition and health; the influence of cold storage preservation on the composition of foods; chemical-technical problems relating to the leather and paper industries; and certain studies in enological technology.

The functions of the bureau also include a wide range of routine work. In addition to the analyses of products coming naturally within the scope of the department of Agriculture, the bureau is especially authorized by congress to examine the supplies of other departments of the government such as foods for the Army, Navy and Panama Canal Commission; post-mark and cancelling inks, inking pads, glue, glycerin, soap, lubricating oils, and linoleum used by the Post-Office Department; disinfectants, lubricating oils and coals used by the government hospital for the insane; dry colors, oils, glue, soap, steel, and miscellaneous supplies used by the Bureau of Engraving and Printing; gums, oils, and alloys used by the Government Printing Office; writing inks, typewriter ribbons, carbon papers, etc., used in the various executive departments where permanence of records is essential; paints, oils, varnishes, chemical glassware and other apparatus used in the Department of Agriculture, and assistance is occasionally given the Treasury Department in the examination of materials regarding which there has arisen a question as to classification for dutiable purposes.

For purposes of administration the bureau is divided into two divisions, seven

laboratories and four sections in Washington, and sixteen food and drug inspection laboratories and two sections for special investigations are maintained in other cities.

The Biochemic Laboratory of the Bureau of Animal Industry is charged with the examination of stock dips and with other chemical studies relating to the work of the bureau. The work of the laboratory includes a large number of routine analyses for which branch laboratories are maintained in various parts of the United States. Much routine and research work connected with biochemical problems is also conducted.

The chief effort of the chemical laboratories of the Bureau of Soils has been the application of the methods of physical chemistry to the problems of the soil. The routine work of the laboratories includes the examination of soils, fertilizers and irrigation and drainage waters to meet the demands of the field forces of the bureau. The following investigations serve to illustrate the nature of the research work that has been done: The solubility of the mineral and organic components of the soil and the physical-chemical characteristics of the resulting solution; the study and practical application of the chemistry of alkali, common carbonates and gypsum, the reclamation and utilization of mine runnings and waste waters for irrigating purposes; and studies relating to humus, the iron compounds of the soil, absorption and toxicity.

The forest service of the Department of Agriculture maintains a chemical laboratory whose province it is to study the

chemical composition of wood in all forms including studies on wood distillation, the analysis and standardization of timber preservatives, the estimation of the tannin and cellulose content of wood and bark, bleaching experiments, etc., and to conduct investigations covering the utilization of various woods and saw-mill waste for paper pulp and allied products. One of the important objects of this laboratory is to experiment on the pulp-making possibilities of various woods with a view to obtaining: First, a pulp with which it will be practicable to replace spruce pulp, the supply of which has notably diminished; second, other pulps that may have properties particularly adapted to the manufacture of special kinds of paper; third, a pulp of marketable value as a by-product from the waste material from saw mill and lumbering operations.

The Office of Experiment Stations of the Department of Agriculture does not maintain a laboratory but employs a number of men with chemical training in connection with the publication of the *Experiment Station Record* and other publications relating to chemical matters. The work of this office is of special interest because of its intimate connection with the forty-eight state agricultural experiment stations of the United States. Although these stations are in part maintained by funds appropriated by congress they are not under the supervision of the federal government, and for that reason can not receive more than a passing notice in this connection.

COMMERCE AND LABOR

The chemical laboratory of the Bureau of Standards has a considerable amount of routine work in the examination of supplies—chiefly for the Department of Commerce and Labor. Its principal work, however, is of a research character including, among other lines, the preparation and examination of substances employed in the construction of standard electrical cells and the investigation of methods used in technical analysis and in the examination of chemical reagents for the purpose of improving their standards of purity.

I have stated briefly the aim and character of the work done in those government laboratories to which appointments are most frequently made, and have given as complete an idea as I could in the time at my disposal of the opportunity they offer for study and research.

Practically all appointments are made from the eligible lists of the Civil Service Commission. The only exceptions are those of chemists whose training and experience peculiarly qualifies them to undertake some special problems and whose appointments are temporary. The examinations from which such eligible lists are established may be broadly divided into four classes.

1. *Those occasioned by vacancies in positions of unusual responsibility or requiring exceptional training and experience.* Examinations of this type are frequently "non-assembled" and no practical questions are asked. Applicants are rated on the courses of study they have completed and especially on the work they have done. The degree of doctor of philosophy or its

equivalent is commonly essential to eligible rating in educational requirements. Under educational qualifications it is obvious that only that work can be recognized for which credit has been received from reputable colleges or universities. Unfortunate as it may be, it is impossible to rate statements of applicants regarding independent study or regarding partial courses in educational institutions from which no credit has been received. Experience is rated, especially in the case of younger men, on the basis of work done under the direction of, or in connection with, experienced chemists, and in laboratories of known reputation. The fragmentary work of teachers who, immediately after their graduation, are thrown upon their own resources and make occasional investigations or analyses in their spare time, can not be rated in an examination unless its value can be demonstrated by the applicant by means of references to publications or otherwise. Such experience is not to be compared with that of chemists whose entire time is devoted to research or analytical work and whose chief effort is given to the study of new problems, the economy of time, the increase of the volume and accuracy of their work, and the improvement of their laboratory technique.

Emphasis is frequently placed on the original contributions applicants have made to scientific literature, which serves as a measure of their ability to meet new conditions and to report the results of their investigations. The evidence they produce of executive ability is rated and their experience in the particular line for which the examination is given. This type of

examination gives the most satisfactory results, and is usually given to fill positions paying a salary of $2,000 or more.

2. *Examinations for experienced and skilled analysts.* In such examination are rated the educational qualifications of the candidates and their experience, particularly in analytical chemistry. Education and experience are usually rated together.

Practical questions are also given in examinations of this type. The questions are chosen with a view to affording a fair test for chemists who have been in practical work for a number of years and to include fundamental principles and methods. The statement is frequently made that examinations place experienced chemists at a disadvantage as compared with recent graduates. While this is true, to a certain extent, the questions given in this type of examination call for a familiarity with analytical chemistry which is rarely acquired by the student and are of a type that any efficient analytical chemist should be able to answer. Moreover, the emphasis placed on education and experience when rating these papers is sufficient to make it practically impossible for a graduate who has not had analytical experience to obtain an eligible rating. The degree of bachelor of science or its equivalent and postgraduate study or practical experience are usually necessary to obtain eligible rating. A special course, incomplete in itself or not preceded by the full training of the secondary schools, will not answer. A mark of seventy per cent. in education and experience is often required for admission to examinations of this type. In such cases a statement of that fact is made in

the published announcements. Even when such requirement is not made, the rating given for a degree following a course of two or even three years is so low that such an applicant must make an unusual showing in his replies to the practical questions to obtain an eligible rating in this examination. An application is useless from one whose only collegiate training was a two or three year course, the entrance requirements of which are inferior to those of reputable institutions giving the degree of bachelor of science.

The applicants who stand among the first on the eligible list established by an examination of this type are commonly paid a salary of from $1,400 to $1,800. Other appointments at a lower salary are also frequently made from the same lists.

3. *Examinations to establish an eligible list from which subordinate appointments may be made.* These examinations are given for the purpose of affording an opportunity to recent graduates in chemistry whose practical experience has been limited. Those who have had practical experience of course receive a higher rating in education and experience, but a passing mark in education and experience is given for a degree of Bachelor of Science or its equivalent from a creditable institution giving a course in chemistry of approximately three years with nine recitation hours a week—three laboratory hours being equivalent to one recitation hour. A higher rating is given those who have had postgraduate experience. In this class of examinations an eligible rating in education and experience is not required, but a low rating in that subject may be com-

pensated by a high mark in practical questions. The practical questions asked in these examinations are of a different character from those of the second class, and it is believed that they are better adapted to the class of chemists for whom they are intended. It is from the eligible list established by this examination that the great mass of appointments to subordinate positions in the various laboratories is made. The salaries paid usually range from $840 to $1,200 per annum.

4. *Examinations for analysts qualified in a special (sometimes narrow) field of work.* Examinations of this class are relatively infrequent and are held for the purpose of supplying needs that sometimes arise in some of the laboratories of the government service for men competent to perform analytical work in some narrow field, but whose services in other branches of chemistry will not be required. The eligible lists so created are not commonly used for appointments in other branches of the service.

It must not be understood that there is a definite system of examinations and that each examination is made to fit into one of the types given above. An examination is usually called to fill a particular vacancy, although it is understood that after that vacancy is filled the list may be used to make other appointments for which the same or lower qualifications are required in the same or other departments. It would not be within the civil service rules, however, to appoint an assistant to the laboratory of the supervising architect's office who has passed an examination calling for widely different qualifications; for

instance, an examination in dairy chemistry.

Transfer from one laboratory to another within the same department is possible at any time when the good of the service does not suffer thereby. Such transfers are sometimes made but are rather unusual. Transfers from one department to another are unusual and can not be made within three years of the date of appointment.

Examinations for chemical positions are not given regularly as is true of examination for clerks. They are given at irregular intervals as need arises, sometimes as many as six or eight chemical examinations of various character occurring in a single year. The civil service commission publishes an announcement of each examination and sends it to all applicants. These announcements are also sent to educational institutions throughout the country. They are also published in SCIENCE. No information regarding examinations is given except that stated on the announcement just mentioned. No definte information is given regarding the character of the questions that will be asked. No copies of questions asked in former examinations are supplied. No information can be given out by the laboratory for which the examination is called other than that contained in the published civil service announcement. It is held that variation from this principle would give an unfair advantage to those who happen to receive it. It is believed that the class of men desired are able to pass the examinations without special preparation, and it is not desired to afford any particular opportunity for such preparation.

With the exception of a few small laboratories where the field work is limited and promotion is not offered, the great majority of appointments to the various government laboratories are to subordinate positions and higher positions are filled by promotion whenever possible. Special qualifications are, therefore, not usually required.

I wish to emphasize the fact that every appointee should have pursued a broad general course of study. The argument is frequently made, and it is doubtless true, that the work for which the majority of appointments are primarily made, that is, the ordinary routine work of the laboratory, could be as well performed at the beginning by men who are not college graduates, and frequently by men whose training in chemistry itself has been very incomplete. It is found, however, that while such men may be satisfactory at the beginning, their potential power is limited. Men with special training are frequently desired for the purpose of conducting special investigations. This special training, however, should have been received in post-graduate study. The ability to conduct research work that is constantly required, the resource essential to emergencies and even the initiative required by those who take a responsible part in the routine work of the laboratory are rarely secured except in men with broad fundamental training.

W. D. Bigelow

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THE FUNCTION OF CHEMISTRY IN THE CONSERVATION OF OUR NATURAL RESOURCES.[1]

BY MARSTON TAYLOR BOGERT.

Received December 24, 1908.

Fellow Members, Ladies and Gentlemen:

At the first conference on Conservation of our Natural Resources, held at the White House, May 13–15, 1908, a most admirable Declaration of Principles was unanimously adopted by the assembled governors, part of which runs thus: "We, the governors of the states and territories of the United States of America, in conference assembled, do hereby declare the conviction that the great prosperity of our country rests upon the abundant resources of the land chosen by our forefathers for their home, and where they laid the foundation of this great nation........ We agree......that the great natural resources supply the material basis upon which our civilization must continue to depend, and upon which the perpetuity of the nation itself rests.... We declare our firm conviction that the conservation of these natural resources is a subject of transcendent importance which should engage unremittingly the attention of the nation, the states, and the people, in earnest co-operation."

The appeal to us is not alone because we happen to be experts in an important branch of science, but because we are more than this—we are patriotic Americans who are deeply interested in everything that concerns the welfare of our country, and such an appeal to the ten thousand chemists of the United States will not be in vain. The dignity and honor accorded a profession depend largely and properly upon the extent to

[1] Presidential address delivered at the Baltimore Meeting of the American Chemical Society, December 30, 1908.

which it ministers to the needs of the community. President Roosevelt has well said, "The life of the nation depends absolutely on the material resources which have already made the nation great."

In considering the matter, the first thing needed is a clear understanding of the nature of the problem so that the chemist can see for himself where he can be of service. I shall, consequently, endeavor to state the case as fully as my time will allow, pointing out incidentally where chemistry is likely to be or has already been helpful. I have no apology to offer if much of the material presented appears to touch chemistry but remotely or not at all. The important thing is that the issues, in their larger aspects at least, should be before us all, for the subject is greater than any one science.

It would be strange indeed if the science which deals with the ultimate constituents of our material universe, their combinations and transformations, could not offer any assistance in the solution of the problem as to how our natural resources may be conserved. It is chemistry that has determined the composition of those materials which make up the earth upon which we live, the atmosphere which surrounds it, and the heavenly bodies beyond. Chemistry studies the properties of the elements and their various compounds and upon these fundamental data our industries rest.

The transformation of the raw material into the finished product consists usually either in changing its external form, as in wood and metal working, weaving, and the like, or there is involved a chemical change, as in metallurgy, fermentation industries, the manufacture of glass, soap, cement, chemicals, etc. Practically all of our manufacturing processes are therefore primarily either mechanical or chemical. In the production of a metal from its ores, or of indigo from coal tar, it is chemistry that points the way, and the more complex the problem the greater the dependence upon this science. In devising new processes and in the discovery of new and useful products, chemistry is again the pathfinder. The community is apt to overlook the extent and diversity of the services rendered by the chemist because of the quiet and unobtrusive way in which the work is carried out.

The measure of a country's appreciation of the value of chemistry in its material development and the extent to which it utilizes this science in its industries, generally measure quite accurately the industrial progress and prosperity of that country. In no other country in the world has the value of chemistry to industry been so thoroughly understood and appreciated as in Germany, and in no other country of similar size and natural endowment have such remarkable advances in industrial development been recorded, and this, too, with steadily increasing economy in the utilization of the natural resources.

That our government realizes the importance of chemistry seems evident from the fact that six of our nine Federal Departments already maintain chemical laboratories where they handle both their own chemical work and that of the Departments of State, Justice, and Post-office, which as yet have no chemical laboratories.

The question confronting us at the outset is: What are the material resources upon which the existence of the human race and its advancement in civilization depend? Suppose we divide them into Extra-terrestrial and Terrestrial.

In the former would fall the most important resource of all—the sun, our great reservoir of light and heat. According to Dr. Pritchett, the sun on a clear day, well above the horizon, delivers upon every square acre of earth exposed to its rays, the equivalent of 7,500 horse-power working continuously. And yet but little of this enormous energy is ever harnessed commercially. The day of the solar engine has not yet come, and, as in the case of our other natural resources, instead of using our income, we are making heavy drafts upon our capital—the solar energy of by-gone ages stored up for us in coal.

The possibilities in utilizing the sun's heat were indicated by the Portuguese priest's heliophore at the St. Louis Exposition, in which, by concentration of solar heat, a temperature of over 3,000° C. was obtained—a temperature at which a cannon ball would evaporate almost like a snowball on a red-hot stove.

We have, to be sure, made use of the sun's light in photography, but we have not yet satisfactorily solved the problem of color photography, while the all-important photo-syntheses accomplished in plants are still but very imperfectly understood. In fact, it is but just beginning to dawn upon us that in the varied and profound chemical and physiological changes brought about through the agency of sunlight, there lies a field for research almost unexplored.

Our terrestrial resources can be conveniently discussed under the headings: I. Atmosphere II. Water. III. Land.

I. Atmosphere.

In the words of Professor Chamberlin: "By a profound regulative system of adjustments and compensations, not only the general temperature of the earth, but the composition of its enveloping atmosphere, are kept relatively constant and within the narrow limits necessary for the existence of animal and vegetable life." Any extensive local pollution of the atmosphere cannot but result disastrously to both vegetable and animal life. The prevention of such pollution is therefore a measure of conservation—conservation of the health and working efficiency of the human being, of other animal life, and of the surrounding vegetation—and one which can often be accomplished to the financial benefit of the

offender. The Bureau of Chemistry of the Department of Agriculture has been for some time investigating the effect of smelter fumes and other trade wastes upon agriculture and forestry.

One of the most frequent pollutants of the atmosphere, particularly in smelting regions, is SO_2. In presence of much humidity, 0.003 per cent. SO_2 in the air is injurious to trees and plants. When oxidized to SO_3 and carried down by rain as sulphuric acid, it materially hastens rock disintegration and soil erosion. There is little excuse for this waste of SO_2, with consequent poisoning of the surrounding air, for, by the older chamber process or the more modern contact process, it can be readily converted into sulphuric acid, that foundation-stone of so many chemical industries. In the manufacture of synthetic indigo, for example, over 50,000 tons of SO_2 which formerly went to waste are now annually reoxidized to SO_3 by the contact process.

At Ducktown, Tennessee, the fumes of SO_2 from the roasting and smelting of the copper ores, together with flue dust, have killed all vegetation for miles around, and the land thus denuded has eroded with startling rapidity. The Secretary of Agriculture cites it as "a striking illustration of the completeness of destruction that may result from erosion in this region when the protecting forest cover is once removed." I am happy to state that the operating company has recently installed a sulphuric acid plant to utilize this SO_2. A similar destruction of surrounding vegetation is now going on in the mining regions of Montana.

In the Rio Tinto mining district of Spain, the lower grade pyrite, in order to partially sulphatize and render the copper soluble, was for years roasted in heaps, with the usual destruction of all neighboring vegetation. It has since been discovered that by keeping moist the heaps of crude ore fines, a slow oxidation and lixiviation of the copper occurs, leaving a pyrite slightly richer in sulphur than before. In the Rio Tinto Company's yards are about 20,000,000 tons of badly roasted pyrite which should have yielded 7,000,000 tons of sulphur of a total market value of $70,000,000. The new process means a saving to the world of about 1,000,000 tons of sulphur annually.

The power latent in the movement of winds is utilized in propelling our sailing vessels and windmills, but the amount thus consumed is but a very small fraction of that available.

II. Water.

Rainfall.—Second only to the sun in importance as a great natural resource is the rainfall, for without an adequate water supply neither vegetable nor animal life can exist. In addition to supporting life, the rain also assists in soil formation by rock disintegration, tempers the climate, and supplies power and navigable streams. The average annual rainfall of 30 inches upon the mainland of the United States is equivalent to

200 trillion cubic feet, or an amount equal to about ten Mississippis. Over half of this enormous total is evaporated and tempers the air, one-sixth is absorbed on the earth's surface, and the remaining third flows off to the ocean. Of the seventy trillion cubic feet annually flowing into the sea, less than one per cent. is utilized for municipal or domestic supply, less than two per cent. for irrigation, perhaps five per cent. for navigation, and less than five per cent. for power. It is estimated that from eighty-five to ninety-five per cent. is wasted in freshets or destructive floods.

Unless properly controlled, therefore, that which is one of our greatest blessings may prove quite the contrary. This control consists in collecting and storing the water during heavy rains, releasing it later as it may be needed. There are two kinds of reservoirs for this purpose, natural and artificial. By the former, I mean the forests, which, like huge sponges soak up the rain and give it out again gradually; by the latter, the dams erected in the hills at the headwaters of our streams.

The damage caused by heavy rains upon land unprotected by forests or storage reservoirs is enormous, including as it does the loss of human lives, destruction of houses and similar property, the washing away of some of the most valuable portions of the soil, the covering of fertile fields with sand and débris, the clogging and rendering unnavigable of our streams and harbors, necessitating expensive dredging operations, the covering of the spawning grounds of fish with silt, and the loss of enormous water power, the saving of which would also mean the conserving of a considerable amount of our fast disappearing fuel supply. The direct yearly damage from floods has risen from $45,000,000 in 1900 to over $238,000,000, while the indirect loss from depreciation of lands and interference with navigation and business is probably far greater. As the water runs off bare and denuded land almost as rapidly as it would from a roof, drought, with all that it entails, quickly follows the cessation of the rains.

The future of all other terrestrial natural resources depends upon the proper conservation and utilization of the rainfall. It is the one vital, underlying problem upon which all others rest, and the chief methods of conserving our water supply—forests and reservoirs—are therefore matters of paramount importance. Forests cannot be grown without water, and the chief factor in the soil problem is also that of water supply. On the other hand, water is of but little service for power purposes or navigation unless the supply is relatively constant and the flow regular, and it is chiefly upon the development of water power that the conservation of our fuel depends.

Purity.—The quality, as well as the quantity, of our water supply is of grave concern. The purity of our drinking water is of vital interest to all

of us, and it is to the chemist and bacteriologist that we must appeal for assurances on this point. The character of the water used is also of very great moment in many industries.

The chief industrial use of water is for the production of steam, but if the water employed is rich in mineral salts the formation of scale will proceed rapidly. Hence, even in such a fundamental engineering operation as steam-power generation the engineer must first consult the chemist as to the quality of the fuel and water to be used. In the United States the average thickness of locomotive boiler scale is 1/16th of an inch. This means a loss of at least 13 per cent. in fuel efficiency: for an eighth inch scale this mounts to 25 per cent., and for a half-inch scale to 60 per cent. Taking 1/16th inch then, as the average boiler scale, this means for our 51,000 locomotives alone, a total annual loss which may be estimated conservatively at 15,000,000 tons of coal. The use of pure water in the boilers reduces the coal consumption and, by decreasing the amount of repairs and prolonging the life of the boiler, reduces also the demand for iron.

In those operations where pure water is indispensable, the cost of impure water is the cost of purification, and it is to the chemist that the manufacturer must generally turn for instruction as to how this purification may best be accomplished. For some uses, as for boiler supply and paper-making, the percentage of mineral matter is of moment, whereas in such industries as brewing, distilling, and ice manufacture, freedom from various micro-organisms must also be taken into account. Impure water means additional cost of production also to bleacheries, dye-works, canning and pickle factories, creameries, abattoirs and packing-houses, nitroglycerin factories, woolen and straw-board mills, tanneries, chemical works, and factories for the manufacture of starch, sugar, glue and soap.

A serious problem arising in this connection is the steadily increasing pollution of our streams and tidewaters by sewage, factory waste, and refuse of all kinds. Practically all of our city and town sewage is disposed of in this way, together, often, with such other refuse as ashes, cinders, garbage, and trash of every variety. In drainage and sewage there is considerable loss of valuable fertilizing materials, the annual loss in phosphorus alone being estimated as equivalent to 1,200,000 tons of phosphate rock. Few people have any idea of the vast amount of solid waste regularly removed and disposed of in our great cities. In New York, excluding sewage, snow, street sweepings and dead animals, the solid refuse (ashes, garbage and rubbish) amounts to over 3,000,000 tons annually, or about 1450 lbs. for every man, woman and child in that city. This huge amount if piled together would occupy over 8,000,000 cubic yards. The removal of that volume of material between here

(Baltimore) and New York would build a canal connecting the two cities 27 feet wide and 10 feet deep. Yet that volume of solid refuse is handled every year by the New York Street Cleaning Department in addition to the items excluded above.

Sawmills, pulp mills, wood distilling plants, tanneries, starch factories, cheese factories, sugar refineries, gas works, chemical works, glass works, dye works, oil refineries, distilleries and breweries, smelters, mining plants, and many other industries pollute the streams with their wastes until the once crystal-clear brook becomes a mixture of water, particles of wood, earth, dust, cinders, fat, oil, soap, coal, wool, hair, refuse of all kinds and different chemical ingredients and colors—a blue-black, sluggish fluid. The waste from sulphite pulp alone in the United States is estimated at over 1,000,000 tons per year, practically all of which finds its way into the streams, although it contains substances related to the sugars and the tannins which might no doubt be recovered with advantage.

Here is a most promising field for the chemist and one in which he has already accomplished much. The manufacturer turns his waste into the stream for the same reason that the smelter allows his furnace gases to escape into the air—because he thinks that it is the cheapest thing to do. If the chemist can show him how he can make more money by saving these by-products and using them, either for the production of heat and power, or for the preparation of valuable commercial substances, he will no longer dump them into the streams.

The Water Supply Branch of the U. S. Geological Survey analyzes river waters to ascertain their potability, their suitableness for manufacturing operations and irrigation, or in relation to soil erosion. Recently, in co-operation with the Rhode Island State Board of Health, it has been making an investigation of various factory wastes now polluting the streams, and it has been found not only that all those so far studied can be satisfactorily purified at a reasonable expense, but also that in many cases it can be accomplished with substantial profit.

The poisoning of our streams and coastal waters also affects that portion of our food supply derived from these sources by either killing off all fish and molluscs or rendering them unfit for food. Inland streams alone provide $21,000,000 worth of fish annually. Brooks in the coal-mining regions once well stocked with fish have become blackened mine drains in which life of any kind is impossible. Although we are annually planting probably six billion fry in our inland and coastal waters, an amount greater than all the rest of the world put together, those best qualified to judge state that the maintenance of fish life in this country is fast becoming impossible. Hence, if the chemist can bring about a cessation of this pollution, he will be assisting directly in preventing

the loss of this food supply, to say nothing of the debt of gratitude which all disciples of Izaak Walton will owe him.

It should not be forgotten that fish supply us also with oil and fertilizing material, as well as substitutes for isinglass, gelatin, and glue.

Although approximately two-thirds of the surface of our globe is covered by water, less than 5 per cent. of our food supply is drawn from the sea. As it seems not unlikely that by 1950 the population of the United States will be at least two hundred millions, the possibility of the sea's contributing more largely to our support is worth considering. Professor Bonnycastle Dale predicts that seaweed will some day be largely used for human food. Seaweeds have, to be sure, been used as food for ages, and in certain parts of the Orient constitute staple articles of diet, but the actual amount so used is at present relatively small. It has been calculated that enough proteids are lost annually in the decay of seaweeds on the sea beaches of the United States to take the place of the total product of our Northwestern wheat fields. In the great Sargasso Sea sufficient nutritious vegetation flourishes and decays to support the entire population of Europe if harvested and prepared in a form suitable for human consumption.

Water-power.—Water constitutes one of our most important sources of power. In the motion of the waves, the rise and fall of tides, and in running streams, vast power is available. The power latent in wave motion and tides is essentially unused at present. The problem is for the engineer.

The United States has now thirty-seven million horse-power available in its streams at a cost comparable to that of steam installation, an amount exceeding the total horse-power at present utilized for all forms of production and transportation throughout the country. To develop thirty-seven million horse power in the ordinary steam engineering plant over eight hundred million tons of coal would be necessary. The theoretical power of all our streams is over two hundred and thirty million horse-power, of which probably one hundred and fifty million could be made available at reasonable cost. If we figure water-power as worth $20.00 per horse-power per annum, one hundred and fifty million horse-power would mean a yearly income of $3,000,000,000.

Of the water-power now available, only about five and a quarter million horse-power is in use and even this is perhaps not used in such a way as to give its maximum efficiency. Every year one million six hundred thousand horse-power wastes over Government dams.

Thirty per cent. of all the horse-power now used is used electrically. At the present rate, it will equal or exceed power mechanically applied by the year 1920. As has been said before, we are entering the Age of Electricity, which means the Age of Water-power and the Age of Elec-

trochemistry. The electrification of our railroads will result in the disappearance of one of the most frequent sources of forest fires—hot cinders from locomotive stacks. As the chief use of coal is for the generation of power, the more water-power used the less the drain upon our coal resources.

Navigation and Transportation.—In the United States there are 282 rivers navigated for an aggregate of 26,115 miles, and this amount could readily be doubled by improvement. Our domestic commerce equals in value the foreign trade of all nations combined, and yet we apparently fail to realize the importance of our inland water-ways to this commerce, for instead of developing them we have the spectacle of their ever-increasing disuse. This has been ascribed to railroad competition, involving reduction of rates when competing with water routes and control of river lines and of terminals, to inadequate river improvement and to the fluctuation and silting up of streams formerly navigable. A little over a year ago the railroads of the country were complaining that it was impossible to handle the amount of freight awaiting shipment, and Mr. James J. Hill was quoted as saying that an immediate expenditure of at least $5,000,000,000 would be necessary to equip the railroads so that they could properly handle the freight presented. And yet the expenditure of one-tenth this sum, or half a billion dollars, would suffice to rehabilitate our inland waterways.

Water transportation generally costs only about one-quarter that of rail transportation. As our railways' freightage in 1906 reached 217,-000,000,000 ton-miles, at an average cost of 77 cents, the shipping of even one-fifth of it by water would have saved the producer and consumer over $250,000,000. The consumption of coal, iron and wood per freight-mile is also much less. Dr. McGee states that but one-tenth as much iron and one-eighth as much coal is needed as for rail transportation. The stimulating effect upon production and commerce of cheap transportation is obvious, while the existence of independent and competing water routes might react favorably upon railroad rates.

Irrigation.—The reclamation of our desert lands by irrigation proceeds apace. Up to date about eight million acres have thus been made available, and the lands thus recovered are among the most productive in our country. Yet in the western half of the United States there is said still to be sufficient fertile land now barren from lack of water to support probably 50,000,000 people who might, in turn, raise enough to support another 50,000,000 in the East. The Reclamation Service believe that in the next twenty-five years it will be possible to develop water supplies sufficient to irrigate twelve million acres more, thus providing farms for about two million people.

The use of water for irrigation does not necessarily interfere with its

use for other purposes also. It may, for example, represent the impounding of heavy rainfalls or melting snows which would otherwise have rushed down the valleys in devastating floods, but which may now serve as a domestic or municipal water supply, or be gradually liberated for the creation of valuable water-power on its way to irrigate lands at a lower level, finally escaping into streams which may thereby be rendered navigable.

Chemistry's services in this field include the furnishing of the necessary explosives for rock blasting, cement and concrete for the dams, the analysis of the water, and the determination of the kind of fertilizers needed on land thus reclaimed. The Bureau of Soils of the Department of Agriculture has been investigating the availability of mine runnings and various waste waters for irrigation.

III. Land.

Amount Available.—Of the three million square miles of mainland of the United States, a little over 1/5 is under cultivation, less than 2/5 is wooded, and 2/5, or an area greater than that of the ancient Roman Empire, is arid or semi-arid. Four hundred million acres of this lie west of the Mississippi River. In 1906 our remaining stock of unoccupied arable land consisted of fifty million acres surveyed and thirty-six and a half million acres unsurveyed, and of this total twenty-one million acres were disposed of in 1907.

The chief means at our disposal for adding to our productive land are by irrigation of regions where the rainfall is insufficient and by drainage of swamps and overflowed lands. In the arid and semi-arid regions only certain areas may be rendered productive by irrigation, while vast tracts, aside from mineral resources, are valuable only for grazing.

Swamps, until recently, covered seventy-seven million acres of our country, or an area equal to all New England, New York and New Jersey combined. Twelve million acres of this have already been drained and are now used for agricultural purposes, and it is estimated that twenty million acres more may be reclaimed—an amount sufficient to support perhaps ten million people. It might be recalled that drainage of the swamps means also the obliteration of the breeding places of disease-carrying mosquitoes.

The engineer may recover arid land by irrigation and swamps by drainage, but the yield from such reclaimed land will depend primarily upon the manner in which it is tilled, and the foundation of modern scientific agriculture is chemistry. But the chemist can do some land reclaiming on his own account. Whenever he shows how agricultural products can be obtained more cheaply in other ways, from industrial wastes, for example, the land devoted to these particular crops is released for the cultivation of other crops. By the discovery of commer-

cially profitable methods of manufacturing alizarin and indigo from coal tar, hundreds of thousands of acres have been set free for other crops. The amount of synthetic indigo now prepared from coal tar is equivalent to considerably over a quarter of a million acres of indigo plants.

Soil.—The action of water and air in producing soil from rock is partly physical, partly chemical. Certain of the rock constituents are made soluble and become plant food or plant poison, while others remain practically insoluble and are reduced to a finely divided state and then constitute the earthy portion of the soil. Hence the salinity of the soil will depend upon the rainfall. If insufficient water passes through the soil, plants will suffer from saline excess; if too much, from saline deficiency. The mean rate of soil formation has been calculated as probably not over one foot in ten thousand years, so that the waste should not exceed one inch in a thousand years, and yet we are informed by the Secretary of the Inland Waterways Commission that over a billion tons of our richest soil, valued at not less than a billion dollars, is annually washed away to clog our rivers and harbors. That amount represents about half a ton per acre, or if placed in one pile, would make a block a mile square and a thousand feet high. It seems certain that the amount of soil carried into the sea by winds is very much greater than this. Dust from the Sahara Desert is occasionally carried as far north as the Baltic Sea. As Professor Chamberlin so aptly puts it: "When our soils are gone, we too must go unless some way is found to feed on raw rock or its equivalent."

Soil fertility is affected not alone by erosion and soil-wash, but also by bad agricultural methods (single cropping and no fertilization), and by the general conditions of rural life. Soil erosion may be prevented by proper reservoirs or forests, by a cover of mulch or humus, by deep cultivation, or by terracing and contour cultivation. Bad agricultural methods are being gradually improved through the labors of the Department of Agriculture; and its Bureau of Soils, in addition to the routine examination of soils, fertilizers, irrigation and drainage waters, has been occupied in applying methods of physical and organic chemistry to soil problems, and in making a special study of the solubility of the various constituents of the soil, the physical-chemical character of the resulting solutions, their absorption and toxicity, the iron constituents of the soil, and the humus. It should not be assumed that the addition of fertilizers is all that is needed to give large crops. There is no more important problem than that of the character and function of the organic constituents of the soil. The popular term "humus" is but the title of a whole volume of organic chemistry but few pages of which

have as yet been accurately translated. The chief differences in soils are not in their mineral, but in their organic constituents.

Agriculture—Agriculture still remains the world's most important industry. Nearly thirty-six per cent. of our people are directly engaged in it and all the rest depend upon it. As Mr. James J. Hill well says: "In the last analysis, commerce, manufacturers, our home market, every form of activity runs back to the bounty of the earth by which every worker, skilled and unskilled, must be fed and by which his wages are ultimately paid." The value of our farm products last year (1907) was about eight billion dollars. We supply one-third of the corn, one-fifth of the wheat, and two-thirds of the cotton consumed by the whole world. Our farms furnish fifty-eight per cent. of our total exports ($919,000,000 out of a grand total of $1,578,000,000), manufactures furnishing 33 per cent., the forests 4.6 per cent., and our mines 2.8 per cent., and 42 per cent. of all the material used in our manufactures comes from the soil. Yet only half our farm land is improved and even this portion yields but a fraction of what it should, and this fraction would be still smaller were it not for the labors of our Department of Agriculture and of its 61 experiment stations (the majority of whose directors, by the way, are chemists) distributed throughout the length and breadth of our land.

We are too prone to gloat over the enormous totals of our crops instead of considering the much more significant item of yield per acre. Were we to examine the latter we should find small cause for pride. On soils originally of high fertility we raise from 12 1/5 to 15 bushels of wheat per acre, while England, Belgium, Holland, and Denmark have averaged over 30 bushels per acre for the last five years. To quote again from Mr. James J. Hill: "In no other important country in the world, except Russia, is the industry that must be the foundation of every state at so low an ebb as in our own. According to the last census, the average annual production per acre of the farms of the whole United States was worth $11.38, an amount that is little more than a respectable rental in communities where the soil is properly cared for and made to give a reasonable return for cultivation." That this is not due to any general loss in the fertility of our soils seems borne out by the fact that our yield per acre for most crops is greater than it has been, rather than less. It is more probably referable to the high price of farm labor in comparison with the price of land. With the exception of our intensively farmed fruit and truck lands, known methods of soil and farm management could double the net profit per acre within five years.

Losses to live stock, grain, etc., by injurious mammals (wolves, rats and mice) exceed one hundred million dollars annually, while insect damage to crops, orchards, grain in storage, etc., is not less than six hun-

dred and fifty million dollars annually. Most of these losses are preventable.

What, then, is the relation of chemistry to this important industry? Liebig, in the preface to his "Chemistry in Its Applications to Agriculture and Physiology" (1840), says: "Perfect agriculture is the true foundation of all trades and industries. It is the foundation of the riches of states. But a rational system of agriculture cannot be formed without the application of scientific principles, for such a system must be based on an exact acquaintance with the means of nutrition of vegetables, and with the influence of soils and actions of manure upon them. This knowledge we must seek from chemistry, which teaches the mode of investigating the composition and of studying the character of the different substances from which plants derive their nourishment."

The chemist's services have included the fixation of atmospheric nitrogen, the elucidation of some of the ways in which atmospheric nitrogen enters into organic combination and of the methods whereby organic nitrogen is prepared for plant food, the analysis of soils and the determination of their relation to plant growth, the analysis of plants and agricultural products and a study of the influence of environment upon their composition, the manufacture of fertilizers and their adaptation to the needs of special soils or crops, the protection of the farmer, by analytical control, from fraud in purchasing the same, methods of utilizing plant food and of conserving it for future use, the establishing of the general principles of plant growth and the chemical changes involved, the replacing of natural dyes and drugs by synthetic articles, the preparation of artificial silk, the mercerization of cotton, the saving of many crops from threatened annihilation by providing effective insecticides and fungicides, the production of valuable substances from former wastes (cottonseed oil, corn oil, gluten from starch factories, cream of tartar from wine lees, etc.) and of industrial alcohol from crop refuse. In the words of Dr. Wiley: "The application of the principles of chemical technology to the elaboration of raw agricultural products has added a new value to the fruits of the farm, opened up new avenues of prosperity, and developed new staple crops."

More than this, the Bureau of Chemistry of the Department of Agriculture, through its chief, Dr. Wiley, was largely instrumental in securing the introduction and enactment of our Pure Food and Drug Laws, and it is the chemist who protects the consumer from adulteration and fraud in his food and drink.

The three substances essential to all plant growth, in addition to water are nitrogen, potash and phosphoric acid. The total value of these substances in our annual crops is estimated at over three billion dollars, to assist in replacing which we manufacture over three million tons of fer-

tilizer per annum. The phosphoric acid needed is obtained from mineral phosphates and phosphatic slags; the potash from the great deposits at Stassfurt, from feldspar, and other sources; the nitrogen, from ammonium salts, animal wastes, Chili saltpetre, and the air. The supply of Peruvian guano, a former source of nitrogen, is already exhausted, and the production of Chili saltpeter is now slightly over two million tons per annum. How long the Chilean deposits can stand the drain is a matter of uncertainty. The fixation of atmospheric nitrogen is therefore one of our most important agricultural problems, and as there are about 34,000 tons of nitrogen over every acre of ground, a commercial process for obtaining nitrogen from this source will forever remove the danger of a nitrogen famine. Much has already been accomplished in this direction, and the basic calcium nitrate and cyanamide processes appear very promising. Uneasiness over the adequacy of our supply of plant food has lately been transferred from nitrogen to phosphoric acid, as our Government experts have reported that the present known supplies of high-grade phosphate rock are likely to be exhausted by the middle of the century.

Among our important agricultural chemical industries are fertilizer manufacturing, wine-making, brewing, distilling, sugar production, cottonseed oil and its products, starch and glucose. In 1907 our brewing and distilling establishments consumed thirty million dollars' worth of barley, fifteen million dollars' worth of corn, and four million dollars' worth of rye, or forty-nine million dollars' worth of grain in all. The beet sugar industry is due to a German chemist, Marggraf by name. By scientific agriculture the sugar content of the beet has been raised to such an extent that while in 1836 it took 18 tons of beets to yield one ton of sugar it now takes less than 7½ tons. The importance of the cottonseed oil industry may be gauged from the fact that the exports of cottonseed oil, oil cake and meal, in 1907, were valued at $27,000,000.

Stock-raising.—As 2/5 of the world's meat supply comes from America, the subject of stock-raising is an important one for us. Upon our public range of three hundred million acres there are approximately fifty million cattle and forty million sheep. The once splendid grazing lands of the West have suffered to such an extent, however, that the public range is greatly decreased both in quantity and quality. As the animal kingdom depends upon the vegetable kingdom for sustenance, this injury to our range is a serious menace to our live stock industry. Fortunately, our Forest Service has already conclusively proven that much of the land no longer suitable for grazing can readily be made so by proper re-seeding and forest protection, and thus restored to its original fine condition.

The beneficent activity of the chemist is exemplified in this industry also, for he has elucidated the laws of animal nutrition and by their ap-

plication secured economy in the use of nutrients. He has taught the farmer how to adapt his feeding-stuffs to the needs of his stock, so as to secure the maximum return in work, flesh, fat, milk, etc., and again by analytical control protects him from fraud when he buys his feed. When diseases attack the cattle the chemist supplies antiseptics and powerful healing drugs. Part of the work of the Biochemical Laboratory of the Bureau of Animal Industry consists in examining stock dips and in other chemical investigations. Light has finally been thrown upon the cause of the mysterious loco-weed disease since Crawford's chemical examination of the plant has disclosed the presence of small amounts of poisonous barium salts. It may be of interest also to those raising forage crops to hear that experiments have indicated that spraying with a 10 per cent. ferrous sulphate solution destroys weeds without apparent injury to the grass.

Not many years since, it was the custom to build slaughter-houses on the banks of streams into which all the refuse could be turned. But chemistry has revolutionized all this, and the old joke about the Chicago packing-houses using every part of the pig, including the squeal, is now not far from the truth. In modern abattoirs and packing-houses the hides are used for leather; the grease is converted into soap, candles, oleo and glycerin; the blood and scrap into blood albumen, fertilizers, and potassium cyanide; the horns and hoofs into jelly, buttons, knife handles, etc.; the feet, bones and heads, into glue, bone oil and bone-black.

The skim-milk formerly often wasted now surrenders its casein, from which so many interesting commercial substances are manufactured.

The chemist has also made some very useful leather substitutes, while the waste from real leather he converts into fertilizer or glue.

Meat, milk, and other products liable to spoil are preserved almost indefinitely in cold storage warehouses, wherein the refrigeration is generally accomplished by liquid SO_2 or ammonia supplied by the chemist.

Forests.—Our total annual consumption of wood, including that used for fuel (100,000,000 cords), is at least one hundred billion board feet, of which forty billion is for lumber. As the total amount of our standing merchantable timber is estimated by the Forest Service as less than fourteen hundred billion board feet, the end of our forests is indicated in twenty to thirty years, as forest fires and other destructive agencies seem quite certain to fully offset new growth. The Secretary of Agriculture has said that a continuation of the present tendencies in the Southern Appalachians will obliterate its commercial forests within the next sixteen years. We are consuming our forests at the rate of about forty-five square miles per day.

The chief uses for our timber are lumber, lath, shingles, fuel, railroad

ties, paper pulp, cooperage stock, mine timbers, tan bark, distillation, veneer, posts and poles. Secretary Will, of the American Forestry Association, has calculated that we consume each year enough lumber to floor the entire state of Delaware, enough lath to fill a train reaching from Chicago to Memphis, enough cooperage stock to build a rick four feet wide and four feet high extending from New York City to Colorado, enough firewood to make a one mile cube, and enough railroad ties to build a railroad around the globe with a sidetrack across the Atlantic, while our annual wood bill exceeds one billion dollars.

Of the above items, lumber is by far the most important. As just mentioned, our annual cut is forty billion board feet, or five hundred feet per capita, against 60 feet per capita in Europe. Lumber is our fourth greatest industry, being exceeded only by food products, manufactures, and textiles. It pays annually about $100,000,000 in wages, operates 33,000 mills, and gives a living to about 2,000,000 people.

In 1905 Mr. J. T. Richards, Chief Engineer of Maintenance of Way, Pennsylvania R. R. system, estimated our annual consumption of railroad ties at ninety to one hundred and ten million, equivalent to over three billion board feet, or nearly half a million acres of forest, and the total number then in use in the United States as six hundred and twenty million. As railroad ties then averaged about 50 cents apiece, this meant an annual charge of $50,000,000 and a total investment of over $300,000,000. Our consumption now is 118,000,000 ties.

In 1906, our consumption of shingles was over two billion board feet,

In 1907, about four million cords of wood, or two billion board feet. valued at about $30,000,000, was converted into paper pulp. One-fourth of this amount, however, was imported. Sixty-eight per cent. of the wood used was spruce. In three months one of our New York daily newspapers would consume a forest as large as Central Park (843 acres), while a single one of its Sunday issues would require 15 acres of forest.

Dr. David T. Day, of the U. S. Geological Survey, reports that in 1905 it took about a cubic foot of timber for every ton of anthracite mined, say seventy million cubic feet annually; for bituminous coal rather less per ton, say 250 million cubic feet per annum; for iron, about twenty million cubic feet; and for precious metals, seventy-five million cubic feet—a grand total of four hundred million cubic feet, or about five billion board feet. Our anthracite mines alone require annually 150,000 acres of forest, and in the famous Copper Queen mine 25 feet of Oregon pine takes the place of every ton of ore extracted.

Our total consumption of tan bark in 1906 was nearly one and a half million cords, worth about $13,000,000; besides 660,000 barrels of extract (half of which was imported quebracho), worth nearly $9,000,000.

Practically all of the bark used was hemlock or oak, and the chief native wood used for extract was chestnut.

In 1904, we produced over thirty million gallons of turpentine and three and a half million barrels of rosin.

In 1906, over a million cords of hard wood, chiefly maple, beech, and birch, were distilled, and products obtained valued at $8,000,000. We use annually over a billion posts, poles, and fence rails, one and a half billion staves, over one hundred and thirty-three million sets of heading, and nearly five hundred million barrel hoops. Furniture consumed five hundred and eighty million feet of lumber in 1905, while matches require annually sixty million feet, or ten thousand acres. A single machine in one of the Detroit factories turns out seven million two hundred thousand matches a day.

The waste of our timber resources is due to fire, careless logging, wasteful mill operations, wasteful use of wood, turpentining, over-production, unjust methods of taxing forest lands, the abandoning of non-productive wooded areas or the clearing of them for agricultural purposes, and the ravages of fungi, parasites, insects and animals. In all, probably seventy-five per cent. of our forest products is generally wasted. Of every one thousand feet of lumber which stood in the forest but 320 feet are used.

Fire is much the most destructive agent to our forests. The loss to the forests from this single cause is colossal, and if we add the loss of buildings burned in our cities and villages, it becomes still more so. We have heard much of panic and business disaster during the past year, but it is quite certain that when we come to cast up the account it will be found that the terrible forest fires of last summer, in their far-reaching injury to the present and immediate future of our country, will greatly exceed the losses incident to the recent panic. The direct damage from last summer's forest fires has been estimated at approximately $100,000,000, but the injury to water-sheds and all the damage which follows deforestation cannot easily be computed. Between 1877 and 1907, forest fires caused a loss of 1956 lives, besides millions of acres of forests. So far, 296 deaths have been reported in 1908 as due to this cause, while the amount of forest obliterated has not yet been ascertained. The annual loss of new growth due to the destruction of seedlings and young trees by fire has been estimated at $90,000,000. The saddest feature of it is that almost all of this huge loss was directly avoidable by ordinary care and intelligence. Forest fires could almost wholly be avoided at a cost one-fifth of the value of the timber annually destroyed.

In the last five years, the total fire losses in buildings in the United States amounted to a billion and a quarter dollars. This was due mainly to the combustibility of the timber construction employed and might have been largely prevented by the use of suitable chemical fire-proofing

compounds. In 1906, we spent $650,000,000 in building operations and the total cost of our fires was $500,000,000 and 6,000 human lives. In all the United States there are about twelve million buildings, in only about 8,000 of which has any serious attempt been made at fire prevention. The latest Government reports show that in forty-nine of our leading cities, fifty-nine per cent. of the new buildings were of wood. If we should include the smaller towns and villages this figure would, of course, be much larger.

As to wasteful logging operations, twenty per cent. of the log (the upper part) is now left in the woods to rot or burn, because it does not pay to haul it to market at present prices. At the current rate of consumption of yellow pine, this is equivalent to a waste of three hundred thousand acres of forest annually. Of all the yellow pine cut in 1907, about half of it, or eight million cords, was wasted. The slab residue from our lumber cut is estimated at fourteen million cords per annum, of which about six million cords is sold for fuel, three and a half million is used by the mills as fuel, and the remaining four and a half million is consumed in their refuse burners.

The damage inflicted by caterpillars, fungi, and animals constitutes another drain upon our forests and shade trees. The ravages of the gypsy and browntail moths, of the elm worm and of the pine blight are familiar to most of us. The drought of the past summer resulted in a plague of caterpillars in many sections of our country and, aside from the havoc wrought in farm crops, thousands of acres of forests were stripped of every green leaf and left as bare as in winter. Previous to this year, the Forest Service has estimated the average annual loss in the East from these causes at fifteen to twenty million dollars. But now the chestnut blight has appeared and the total annihilation of all these beautiful trees in the East is threatened. Already the damage is estimated at ten million dollars, and no way has yet been found to cope successfully with it. It is to be hoped that the chemist can help here. I would remind you that it was a chemist—Pasteur—who, by his investigations of the diseases of the silkworm, saved the silk industry of France, and by his study of the "diseases of wine" saved that industry from heavy loss.

The only business that uses the forests without much waste is the tannin extract industry, which sweeps the chestnut and oak forests almost clean, taking young as well as mature trees.

Can the chemist do anything to conserve our timber supply and postpone the exhaustion of our forests? In spite of the fact that *for the present* he must plead guilty to using the forests for the production of paper, distillation products, tannin and naval stores, I say without fear of suc-

cessful contradiction that he is easily one of the chief conservers of our forests.

In the first place, chemistry has put into the hands of the builder non-combustible materials, such as iron and steel, cement and concrete, brick, plaster, terra cotta, tiles, porcelain, pottery, stoneware, and all kinds of metallic furnishings and finishings, thereby directly reducing the demand for lumber. The production of cement in 1890 was 335,000 barrels; in 1907, it was 52,000,000 barrels, worth $56,000,000. The quality of the cement, further, depends primarily upon the accurate analysis of its ingredients. The modern methods of reinforcing concrete admit also of slender construction. The plasticity of the concrete when first applied and its monolithic character when set are great advantages, besides which, in contradistinction to wood construction, it grows stronger as it grows older. If, nevertheless, the builder finds it necessary to use wood or other combustible materials, the chemist shows him how to treat these substances so as to render them fireproof. A small fraction of the amount annually lost in fires would probably suffice to fireproof all our wooden construction. If fireproofing is neglected, the wood must at least be protected from weathering and decay, and for this purpose the chemist provides paints, varnishes, etc. Our annual consumption of paint amounts to one gallon for every man, woman and child in the United States. In other cases, the life of the wood is prolonged by creosoting, or treatment with similar preservatives, which protect it from weather and water, from attacks of marine borers, of molds, fungi, etc. The application of preservatives also permits the use of inferior woods, for it has been found that the latter when creosoted, outlast the finest quality of untreated timber.

In fighting the inroads of caterpillars, insects, etc., the chemist is called upon to supply the necessary insecticides, fungicides, etc.

To offset the damage caused the forests by the paper pulp industry, the chemist is busily searching for some other cheap source of cellulose, particularly in such waste products as sawmill refuse, corn stalks, cotton stalks, bagasse, the straw from various grains, etc.; and, meanwhile, has pointed out that other trees, for example, the white fir of the Pacific coast, can be used instead of the fast disappearing spruce.

For acetic acid, wood alcohol and acetone, we must still call upon the forests, but formic acid from generator gas is already proving a serious rival to acetic acid for certain uses.

In the matter of tanning, the chemist has already partly repaid his debt to the forests by the discovery of chrome tannage for upper leathers, and the action of formaldehyde upon albuminoid substances. The discovery of a satisfactory mineral tannage for heavy hides will square the account. Tannin is also being recovered from various waste products.

In 1906, $15,000 worth of tannin extract was made in Florida from palmetto roots.

Thanks to the labors of our fellow-member, Professor Herty, less dangerous and more scientific methods of turpentining are gradually being introduced in the South.

The chemist also helps by showing how valuable by-products may be obtained from what would otherwise be wasted. Thus, turpentine and rosin may be recovered from pine sawdust and the residue used for pulp, or sawdust may be converted into a water-proof artificial wood by treatment with glue and bichromate. Formerly sawdust was also used as a source of oxalic acid, but the chemist has found a cheaper way of making it from the CO of furnace gas.

According to our consular reports, a factory has recently been erected at Grossalmerode, Germany, for the manufacture of glass telegraph poles.

Formerly all alkali for soap manufacture was obtained from wood ashes. If we still had to depend upon wood for all the alkali we used the drain upon our forests would be a heavy one, but the chemist has shown how alkali can be obtained by the electrolysis of salt, and there is enough salt in our ocean, according to Dr. F. W. Clarke, to cover the entire United States a mile deep, or, according to Professor Joly, the entire globe to the depth of 112 feet, so we are in no immediate danger of a scarcity of alkali.

That the Forest Service appreciates the helpfulness of chemistry is evidenced by its operation of a chemical laboratory in connection with its work.

President Roosevelt has said that "The forest problem is in many ways the most vital internal problem before the American public to-day." The importance of the forests arises not solely from their being the source of our timber, but, still more important, because of their bearing upon our water supply. In forest cover, not only is erosion impossible, but the rains of summer evaporate more slowly, the snows of winter melt less rapidly, the run-off is more gradual and regular, floods cease, and the streams become available as sources of water-power.

Growing scarcity of timber means a steadily rising price for it and a correspondingly increased burden upon individuals and industries using it. With the failure of the forests, the lumber business, our fourth greatest industry, will cease; mining will become more expensive and the price of coal, iron, etc., will rise. High rates for coal and iron will affect the railroads. With raw materials and transportation higher, manufactured articles of all kinds will be dearer. Agriculture will be affected not only by the higher cost of the necessary tools, but also by alternate devastating floods and drought, and the absence of protection from high

winds. The last of our once noble army of game will disappear with the disappearance of their homes—the forests. Reduction of the summer stream-flow will raise its temperature to a point where fish life may no longer be possible. An important climate-tempering factor will be missing. There will no longer be the cool and bracing air of the woods for the restoration of lost health and strength, nor the peace of the deep forests where, as Thoreau so beautifully expresses it, "Nature seems too happy to make a noise." As Mr. Pinchot, our chief forester, so truly says, "When the forests fail, every man, woman and child in the United States will feel the pinch."

The terrible results of total deforestation are before us in many Oriental countries. Babylon and Antioch, Tyre and Sidon, as well as one-third of China, have been ruined by deforestation. One thousand years before Christ the forests of Lebanon were famous throughout the world, and Tyre and Sidon were great lumber markets. Solomon had 80,000 lumbermen at work there cutting timber for the Temple. The region about Jerusalem was fertile and it was no exaggeration then to call it "a land flowing with milk and honey." Its forests have vanished and to-day it is barren and desolate. As Mr. R. A. Long says: "The rain-bearing clouds still float above the mountains of Syria, but they pass on over the bare and heated rocks, and the brooks and small streams of Palestine no longer exist." Mesopotamia, the traditional site of the Garden of Eden, must have been in ancient times one of the most beautiful spots in the world. Herodotus says that the culture of the grape could not succeed there on account of excessive moisture. To-day it is a sterile, treeless waste, and the Euphrates River, once the source of an abundant water supply, is now largely swallowed up in the sands of the desert before it reaches the Persian Gulf.

It may be assumed that as all this happened centuries ago, there is no immediate cause for worry. We should not be deceived on that score, for the effects of extensive deforestation are not long in appearing. Hough, in his "Elements of Forestry," says: "The Khanate of Bucharia presents a striking example of the consequences brought upon a country by clearings. Within a period of thirty years this was one of the most fertile regions of Central Asia, a country which, when well wooded and watered, was a terrestrial paradise. But within the last twenty-five years a mania for clearing has seized upon its inhabitants and all the great forests have been cut away, and the little that remained was ravaged by fire during a civil war. The consequence was not long in following and has transformed the country into a kind of arid desert. The water courses have dried up and the irrigating canals are empty. The moving sands of the desert, being no longer restrained by barriers of forests, are every day gaining upon the land, and will finish by trans-

forming it into a desert as desolate as the solitudes that separate it from Khiva."

The forest problem has been solved in Europe, why not here? Germany's forest is to-day three hundred per cent. better than it was seventy years ago, the yield per acre is worth seven-fold what it was, and the improvement is steadily advancing. With proper management, our forests can be made to yield four times what they do now.

Mining and Minerals in General.—In the first place, let it be kept clearly in mind that metallurgy is a branch of applied chemistry, being founded upon chemistry and engineering.

The total value of our mineral products in 1907 was over two billion dollars, and of our manufactures probably over seventeen billion dollars. The value of our mineral products is now four times what it was twenty years ago. In the past fifty years we have taken out far more of the mineral wealth of the earth than in the 350 years preceding. John Hays Hammond says that "The culmination of our mining industry is to be reckoned in decades, and its declension, if not practically its economic exhaustion, in generations, not in centuries." In general, it may be said that the seriousness of our mineral problem lies in the fact that these are resources which cannot be renewed. It may be urged that, as matter is indestructible, metals once won from their ores should not waste but accumulate, and this, no doubt, is partly true. It does not apply, however, to our fuels, for when carbon is once burned to CO_2 it is no longer available as fuel until by the slow processes of vegetable life, some of it is fixed in plants and gradually reduced through peat to coal again. Six times as much of our carbon is now locked up in mineral carbonates unavailable for fuel as there is in the form of coal.

The life of our mineral resources may be prolonged by the discovery of new supplies or satisfactory substitutes, by avoiding wastes in mining and extracting ores and the discovery of methods which will render low-grade or other ores available, by a more complete utilization of the latent possibilities of the ore including the recovery of all by-products, and by preventing loss of life and property through fires and explosions.

The chemist is helping in many of these lines. It is to him that we must usually turn for the production of satisfactory substitutes, for devising new processes, and for the utilization of by-products and wastes. It was the pioneer investigations of Bunsen and DeFaur which pointed the way for the use of furnace gases in most of those directions in which they are now employed.

In smelting operations, the chemist must analyze the raw materials—ore, coke, limestone, etc., the intermediate products—the pig-iron if steel is to be made—and the final products, including the furnace gases and slags.

Without the explosives of the chemist, modern mining, as well as many

great engineering works, would be impossible. After the precious metals have been extracted, it is powder which stands guard over them, as it does over all the accumulated wealth and property of this and other nations. On the other hand, a chemist, Sir Humphry Davy, by his invention of the safety lamp, has done more than any one else to protect the miner *from* explosions. It is worth noting that the authorities did not appeal to a chemist until all suggested engineering methods had proven powerlesss to avert the terrible "firing" of the mines. The new sodium dioxide compound "oxone" may prove of value in mine accidents, for it absorbs CO_2 with liberation of oxygen. The oxygen upon which rescuers now depend is also the result of the skill of the chemist.

In 1907, the total value of our fuels, including by-products, was over one billion dollars, divided as follows: coal, $615,000,000; coke, $112,000, 000; petroleum, $120,000,000; natural gas, $53,000,000; artificial gas, $126,000,000, and coke by-products $7,000,000, or one billion thirty-three million dollars in all.

Excluding carbon present in carbonates, which is not available for fuel, the remaining carbon in our lithosphere, mainly coal, amounts, according to Clarke, to only 0.03 per cent., or 1/150th the amount of our iron. We are therefore much more likely to discover new mines of iron than of coal. Further than this, the development of other metals and alloys, and the use of concrete, will operate to reduce the drain upon our iron mines, but the case of our fuels seems much more serious. The likelihood of our discovering any satisfactory substitute for carbon as a fuel appears remote indeed. We must therefore reduce the demands upon our fuel supply, and this can be most effectively accomplished by the development of our water-power, as already pointed out. Dr. I. C. White, state geologist of West Virginia, puts it none too forcibly when he says: "Just as sure as the sun shines, and the sum of two and two is four, unless this insane riot of destruction and waste of our fuel resources which has characterized the past century shall be speedily ended, our industrial power and supremacy will, after a meteorlike existence, revert before the close of the present century to those nations that conserve and prize at their proper value their priceless treasures of carbon."

Natural Gas.—In heating value, the total original stock of natural gas probably rivaled or even exceɪlep our total coal deposits. According to Dr. White, some individual wells have droduced gas at the rate of 70,000,000 cu. ft. daily, equal in heating value to 70,000 bushels of coal, or to nearly 12,000 barrels of oil.

Natural gas is the ideal fuel. Wood and coal must be converted into gas before they burn, but here is a rich fuel already in the gaseous state and stored under such pressure that not only will it transport itself through suitable pipe lines to great distances, but in some instances this pressure

is sufficient to drive engines without burning the gas at all. In tests conducted at Pittsburg to determine the relative heating value of natural gas and of the best coal, the gas gave 83.4 per cent. of its theoretical efficiency, while the coal gave but 60.9 per cent. And yet it is estimated that at least one billion cubic feet of this incomparable fuel, equivalent in heating value to approximately one million bushels of coal, is being wasted daily. Dr. White states that from a single well in Eastern Kentucky gas streamed for twenty years, with no attempt to check or utilize it, the total value of which was three million dollars.

At the present rate, our natural gas will probably be exhausted by the middle of the century. The value of the natural gas produced in 1907 was $53,000,000. In 1906, four hundred billion cubic feet of gas, equivalent to nine million tons, was produced. Natural gas is used to some extent for illumination, by enriching it or burning it in Welsbachs.

Petroleum.—According to Dr. David T. Day, of the U. S. Geological Survey, the total production of petroleum in the United States in 1907 was approximately one hundred and sixty-six million barrels, valued at $120,000,000, or forty million barrels more than in 1906, this increase being greater than the total annual production for any year previous to 1889.

Some oils are used practically crude for lubrication or burning. As a fuel for vessels, petroleum has many advantages, and the British Navy has been conducting tests with a view to using it on many of their ships. Most petroleums, however, are subjected to careful rectification and chemical purification. At one time the waste in the oil business was enormous, as only the kerosene was saved. Now, with the exception of occasional fires and the relatively small amount sprayed into the air with escaping natural gas, and the seepage from earth-pits used for storage of petroleum in certain sections of the country, the loss is very much less, for chemistry has not only shown how a greater yield of kerosene may be obtained, but also how all the by-products—gas, gasolene, naphtha, lubricating oils, paraffin, vaseline, and coke—may be saved with considerable financial profit. Certain of these distillates are used for the production of high candle-power illumination, as in the Pintsch and Blau gas processes.

The rapid growth in the use of gasolene engines has developed an enormous demand for this petroleum fraction. The most promising substitutes for gasolene appear to be industrial alcohol and the benzene from by-product coke ovens. The former of these, although giving a much higher efficiency as a fuel, is still too expensive to compete with gasolene except in special cases. The latter, as our number of by-product coke ovens increases, is likely to play a more and more prominent part in this field.

According to the U. S. Geological Survey, the known supplies of petro-

leum cannot be expected to last much beyond the middle of the present century.

Coal.—Our total original stock of coal has been estimated at two thousand billion tons, of which we have used to date about seven billion and wasted three billion. The volume of our coal has been computed as equivalent to an eight-mile cube. Our production in 1907 was three hundred and ninety-five million tons of bituminous, worth $451,000,000, and seventy-six million tons of anthracite, worth $164,000,000, or a total of four hundred and seventy-one million tons, valued at $615,000,000. This is over 37 per cent. of the world's production, and is equivalent to five tons per capita. Dr. Goss has calculated that the total weight of coal produced in 1907, if in the form of market-size bituminous coal, would make a windrow of triangular cross-section, 46 ft. wide and 32 ft. high, extending from New York City past San Francisco and 200 miles out into the Pacific Ocean.

At the present rate of increase, one-eighth of our total supply will have been consumed by 1937. All of our anthracite will be exhausted in 60 to 70 years, while our bituminous coal may last ten times as long. To quote once more from Mr. James J. Hill: "When fuel and iron become scarce and high-priced civilization, so far as we can now foresee, will suffer as man would suffer by the gradual withdrawal of the air he breathes." Long before final exhaustion, it will be necessary to carry the workings deeper, increasing the difficulty of mining and the danger to the miner, and to use lower-grade material, while the price to the consumer will necessarily steadily rise. Already Great Britain's industries have felt the check from similar causes, as shown in her higher cost of production. In 1907, 3125 people were killed and 5316 wounded in coal-mining operations in this country. That means one human life for every 145,000 tons of coal mined, or five deaths out of every 1000 employees, a death-rate four times that of Europe.

The greatest waste of our coal supply is in our imperfect processes for rendering available its latent energy. In the average power plant not over ten per cent. of the potential energy of the coal is utilized. About one-quarter of our total coal consumption is in locomotives, and the loss due to boiler scale has already been discussed. The advent of the gas engine and producer gas has marked a long step in advance, for not only can the percentage of coal energy utilized be raised to 18 or more, but, what is even more important, low-grade coals, culm, slack, lignite, bituminous shales, etc., become available. On the average, the same coal will give 2½ times as much power in a gas engine as when burned under a boiler. If we could harness all the potential energy of the coal, our supply of fuel might be considered more nearly inexhaustible. Briquetting of fines also reduces waste, and it has been found that good briquettes

make a hotter fire than ordinary lump coal, and that there are no cinders thrown and no smoke if properly fired.

With the exception of a few narrow strips in the West, there are no first-class coking coals known in the United States outside of the Appalachian Basin. Of the one hundred thousand coke ovens of the United States, thirty-five thousand are practically within sight of Pittsburg, and they are consuming these splendid coking coals at such a rate that Dr. White asserts that by the beginning of the next century there will probably be no coal within one hundred miles of Pittsburg.

In 1907, over forty million tons of coke, valued at nearly $112,000,000, were produced from about sixty-two million tons of coal. Only five and a half million tons of this, or less than 14 per cent., were obtained in by-product ovens. About fifty-four and a half million tons of coal were coked in beehive ovens. This involved a waste of one hundred and forty-eight billion cubic feet of gas, worth $22,000,000; four hundred and fifty-thousand tons of ammonium sulphate, worth a similar amount; and nearly four hundred million gallons of tar, worth $9,000,000. The gases evolved in coking ovens have high calorific power. Dantin estimates that in modern ovens only 65 per cent. of this is necessary to effect the carbonization. The remaining 35 per cent. amounts to about 3700 cu. ft. of gas, equivalent to 420,000 calories, per ton of coke produced. As a gas engine of one thousand kilowatt power absorbs about 3600 calories per kilowatt, the power wasted in beehive coking amounts to over four billion kilowatts or about three billion horse-power. We are therefore wasting enough power to establish a great manufacturing centre, enough ammonium sulphate to fertilize thousands of acres, enough creosote to preserve our timber, and enough pitch and tar to roof our houses and briquette our slack and waste coal.

Lignites have been found to give not only an excellent yield of gas, but also tar, oils, paraffin, and other valuable by-products. It has recently been claimed that one ton of dried peat can be made to yield one hundred and sixty-two liters of pure alcohol and about 66 pounds of pure ammonium sulphate.

In 1907, four million tons of coal were consumed in the production of thirty-four billion cu. ft. of coal gas for heating and illumination, worth $36,000,000, in addition to over one hundred billion cu. ft. of water and oil gas, worth $90,000,000, or $126,000,000 worth all told.

The value of coal to the consumer depends upon its heating power, the percentage of water it contains, the amount and character of its ash and clinker, and how extensively it corrodes the grate-bars. For an authoritative answer to these and similar questions, the chemist must be consulted

The composition of furnace and flue gases has been determined by

chemical analyses in smelting and other industries, and by utilization of these gases for pre-heating and for the generation of power, the amount of coal consumed has been reduced, and in addition valuable by-products recovered. In gas illumination, the invention of the Welsbach mantle has greatly increased the amount of light obtainable from a given weight of coal and correspondingly reduced the drain on our coal resources. The conversion of carbon into acetylene through calcium carbide should also be mentioned.

Iron.—The total production of iron ore to date has been calculated as seven hundred and fifty million tons, believed to be 1/13th of our original stock. The production in 1907 was fifty-three million tons of ore, or twenty-six million tons of pig iron, worth $530,000,000. This is nearly half of the world's total output and is equivalent to twelve hundred pounds ore or six hundred pounds pig iron per capita. The total amount of pig iron produced by the whole world in the 350 years before 1850 would now be produced by the United States alone in a little over four years. At our present rate of increase, it is predicted by Mr. Carnegie that in 40 years we shall see the end of all large deposits of high-grade ore now known. Half of our original total will be exhausted by 1938, and only lower grades left, while all now deemed workable will be gone long before the end of the present century. The lower the grade of ore, the larger the amount of coal necessary to smelt it, and the higher the price of the product.

As iron, according to Clarke, composes four and one-half per cent. of our lithosphere, the chances of our discovering other important deposits of ore seem far better than in the case of most other metals or of coal. The development of iron alloys is a most promising field, and among these we may find satisfactory substitutes for other metals now mroe seriously threatened with exhaustion. The production of ferrosilicon may render available certain siliceous ores hitherto regarded as unworkable.

The chief use of iron is in the construction of railroads and of buildings. To move 1000 pounds of heavy freight ten miles by rail requires about an equal weight of iron in engine, steel cars, tracks, etc. As already mentioned, the development of water transportation should materially reduce this demand for iron. In building operations, concrete is helping out not only as a substitute for iron and steel, but also as a protective covering for metallic pillars and girders.

The iron and steel industry rests mainly upon chemistry and is under chemical control at every point. The production of steel by the Bessemer process depends upon the combustion of the carbon and silicon of the pig iron, the heat of combustion serving to maintain the mass in the molten condition.

By the utilization of what was formerly the waste heat of blast furnaces

to raise steam for the blowing engines and to preheat the blast, the amount of coal necessary to produce one ton of pig iron is only a quarter what it was. The slags are now largely used for the production of cement and concrete, as fireproof packing for steam pipes, as ballast for railroad tracks or for macadamizing highways, and for building purposes (slag brick, slag blocks, etc.), while those rich in phosphorus, as from the Thomas-Gilchrist process, are extensively employed in fertilizers. In the words of Mr. James Douglas: "When all the volatile products of the blast furnace . . . . . are deprived of their heat-giving properties and their chemical constituents, and when the slags, as well as the metal, have returned their heat to man instead of to the atmosphere, and the slag itself has been turned into cement or some other useful article, it will be a question as to whether the pig iron is the principal object of manufacture or one of the by-products."

The safety and comfort of travel on our railroads depend in large measure upon the skill of the chemist in testing the character of the materials employed in their construction and operation. It may be only a delay from a hot box due, perhaps, to a poor quality of lubricant, or it may be a disaster from the failure of a signal or headlight at a critical moment, or the breaking of an axle or locomotive part because of steel brittle from impurities.

Other Metals.—In the past twenty-five years our production of silver has increased 22 per cent., of gold 63 per cent., lead 150 per cent., zinc 537 per cent., and copper over 950 per cent.

The copper production of the United States in 1907 was 435,000 short tons, valued at $174,000,000. In the opinion of experts, the crest of our known reserves of high-grade copper ores is clearly past and we are using lower and lower grades with increasing cost of production. If, as has been affirmed, we are entering upon an age of electricity, the adequacy of our copper supply is a matter of serious concern. Chemistry has played a prominent part in copper metallurgy. The matte is now bessemerized and 70 per cent. of our total product is refined electrolytically.

The avoidable waste in mining copper, zinc, lead, silver, and many other metals, is estimated as at least 30 per cent., but the values now locked up in the Arizona slags, the Comstock slimes, and the Anaconda tailings, will sooner or later be recovered by chemistry.

Chemistry has finally pointed the way by which *aluminum* may be obtained cheaply in large amount from its ores. Last year, our consumption of aluminum was 8500 tons, worth $5,000,000, the world's production for 1907 being estimated as 20,000 tons. The commercial utilization of aluminum and its alloys is writing a new chapter in our mineral industry. To appreciate what this development of aluminum means it is proper to recall that our total supply of it is nearly twice as great as that of iron,

and over 800 times that of our copper. Aluminum is already replacing copper for certain electrical purposes. A large part of the power now generated at Niagara is distributed through aluminum alloy cables. It is also used for automobile castings, for airship construction, and for utensils of various kinds. The use of finely divided aluminum in Goldschmidt's "thermit" process of welding and casting is an important application of one of the chemical properties of aluminum.

A good example of the economy often accomplished by chemical investigation and discovery is furnished in the case of ultramarine. Many years ago when this was made by powdering the mineral lapis lazuli, it sold for more than its weight in gold. Now that the chemist has discovered how to make the same material from such cheap substances as kaolin, sodium sulphate and carbonate, charcoal, sulphur and rosin, the price is only a few cents per pound.

In the field of the *precious metals*, chemistry has contributed, among other things, the cyanide and chlorination processes, through which formerly rejected low-grade ores and residues have been compelled to give up their gold. The gold production of the world between 1851 and 1907 was three times that produced between 1493 and 1850. The value of our specie, upon which every commercial transaction rests, is determined by the chemist, while the green ink used in printing our banknotes, and to which they owe the name of "greenbacks," was invented by a former president of this Society, Dr. T. Sterry Hunt.

The chemist lets nothing escape unsearched. The sweepings from mints and from the shops of workers in precious metals, as well as the water in which the workmen wash their hands, are all made to relinquish the gold or silver they contain. Even waste photographic solutions must disgorge their silver before they are released. The invention of electroplating led to the extensive use of plated articles instead of solid ware and thus reduced somewhat the drain upon certain of our mineral resources.

The supply of platinum has been for years so limited that the price has ranged high. Chemistry has now put on the market vessels of transparent and opaque quartz which seem likely to replace platinum for some chemical purposes.

Many other instances might be cited where chemistry has made important contributions to the economic utilization of our mineral resources, such as the carbonyl processes of Mond, for example. But there is still much to be done in improving the present wasteful methods of smelting certain of our ores, and we may look for great advances in this direction through the rapidly developing and most promising field of electrometallurgy. This address, however, has already far outrun its proper bounds, yet I think that what has already been said fully justifies the statements

in the reports of the Twelfth Census of the United States that "Probably no science has done so much as chemistry in revealing the hidden possibilities of the wastes and by-products in manufactures. This science has been the most fruitful agent in the conversion of the refuse of manufacturing operations into products of industrial value . . . . . Chemistry is the intelligence department of industry." It does not skim the cream of other men's labors but is itself a creator of wealth.

I have touched but incidentally upon the chemist's services in conserving the health of the community, a field in which his prominence is recognized more clearly every day. Our food and drink is scrutinized by him to shield us from fraud and disease, our clothing bears the imprint of his handiwork, our homes are better lighted through his labors, and in times of serious sickness it is from his hands that the physician receives some of his most potent drugs for the relief of pain, for the production of anesthesia, and for the rescue of the sufferer from the very brink of the grave. In his fight with disease and death, the physician has no more powerful ally than the chemist.

In view of all this, I cannot agree with President Howe's statement in a recent number of *Science* (**28**, 547, Oct. 22, 1908) that "This work of conservation is the work of the engineer." The engineer can contribute largely to the solution of the problems involved, he will perhaps be the largest single contributor, but there are others who can also render valuable service in this direction, of which number the chemist is certainly one.

Of the various factors upon which the success of this conservation movement depends, none is more important, in my estimation, than that of awakening the producer and manufacturer to a proper realization of the value of science to our industries.

Bacon has said "I hold every man a debtor to his profession," and here, gentlemen, in assisting in the conservation of our natural resources, is an unrivaled opportunity to pay that debt and in so doing to bring added dignity and honor to our profession.

THE CHEMICAL INDUSTRIES OF AMERICA

By CHARLES E. MUNROE, Professor of Chemistry,
George Washington University

Read at the Philadelphia Meeting, Dec. 8, 1909

The topic which you have done me the honor to invite me to address you upon appears on first consideration quite specific, but investigation shows that this is not quite the case. Thus we find the popular idea of a chemical industry to be one producing acids, alkalies, salts, explosives, fertilizers, dyestuffs and extracts, pigments, distillation products and elementary substances like bromine, phosphorus, sodium and others, and the officials of the U.S. Census Bureau in 1880 in fixing a classification, styled in the various censuses "Chemical Production" or "Chemicals and Allied Products," adopted this popular view.

In discussing this, I have said, (1)* "A reason for the variation in the industries included at the different censuses is found in the very general and indefinite title used, for in the strictest technical sense every material thing is a chemical, and accordingly every industry in which the materials used undergo a chemical change in the process of manufacture, as in the smelting of iron from its ores or the production of leather from a hide, may be considered as a chemical industry. It is evident that if this view of the significance of the title were taken, "Chemicals and Allied Products" would properly cover every manufacture except those like furniture-making, machine construction, or textiles, in which the material remains unchanged in composition during the manufacture, but is turned, or cast, or woven into other shapes. The popular idea of the term limits its application, but admits as chemical industries the manufacture of gunpowder, fertilizers, and similar mixtures, whose ingredients undergo no chemical change during the process of compounding the mixtures. It

* Bull. 92: Census of 1905, page 9, by Charles E. Munroe.

thus bcame necessary to decide arbitrarily upon the industries to be included. Those so included at the census of 1905 may be divided into the following classes: Sulphuric, nitric, mixed and other acids; sodas; potashes; alums; coal-tar products; cyanides; wood distillation; fertilizers; bleaching materials; chemicals produced by the aid of electricity; dyestuffs; tanning materials; paints and varnishes; explosives; plastics; essential oils; compressed and liquefied gases; fine chemicals; general chemicals." These were consequently divided into nineteen different classes which were given separate treatment. The combined statistics for these classes for the censuses of 1900 and 1905 are set forth in the following table, the statistics of these two censuses only being compared because they alone dealt with the same materials:

Table I

CHEMICALS AND ALLIED PRODUCTS OF UNITED STATES, 1900 AND 1905

	Establishments. Number.	Wage Earners. Number.	Total Wages. $	Materials Used. Cost $	Products Value. $
1905	1,786	59,198	29,515,863	176,400,680	282,169,216
1900	1,691	46,700	21,783,335	124,018,044	202,506,076
Increase	95	12,498	7,732,528	52,382,636	79,663,140
Per cent of incr.	5.6	26.8	35.5	42.2	39.3

From Table I it is observed that there was an increase in every item enumerated, but that, not only was the actual increase in the number of establishments less than that of any other item, as was to be expected, but that the percentage increase was less. This indicates that the growth of these industries was rather by increased production of existing establishments than by the creation of new ones. In fact in a more detailed analysis it was found that in some industries the number of establishments had actually decreased, though each of the other items, as enumerated in Table I, showed an increase.

The greater percentage increase in wages over that of the percentage increase in wage earners shows that the lot of the latter was improved and possibly indicates that a better class of labor was employed and, since the percentage increase in the number

of salaried officials for these establishments was 29.6, while the percentage increase in salaries was but 32.4, it is obvious that the wage earners fared, on the whole, better than the salaried officials.

A wholesome feature to be observed is that while the increase in the number of men employed was 12,104, the increase in the number of women employed was but 413, while there was a decrease of over 10 per cent in the number of children employed. I speak of this condition as a wholesome one because, outside of the clerical and perhaps analytical work, the duties to be performed in these establishments is essentially man's work.

The greater percentage increase in the cost of materials used as compared with the percentage increase in the value of the products shows the growing necessity of intelligent and careful management and skillful workmanship to prevent waste and to increase yields. This is emphasized by examination of the additional item of miscellaneous expenses which, while less in the total than any of the values given in Table I, showed an increase of 77.2 per cent.

As indicated, the Census classification of "Chemicals and Allied Products" which gave the data just discussed, is a purely empirical one, and it deals with but a very few of the true chemical manufactures of the United States. It is not possible to derive from the returns, of the various industries as taken, the data for an exact scientific classification such as has been referred to above. Yet, in order to arrive at a better conception of the application of chemistry in manufacturing industries and its magnitude, we may follow such a scheme of classification as that employed in many chemical technologies, though here again we meet with the difficulties common to classification and we are compelled to include in our data some of the products of purely physical processes, either because these processes are operated collaterally with, or are related to, the predominating chemical processes, or else because the products are closely associated with the chemical products. In assembling this data it should be said that in order to compare the data of the different epochs one must first eliminate from the data of 1900 the returns for neighborhood industries, because the census of 1905 was a factory census and considered only the results of manufacture as carried out in factories, and not solely for consumption at the point where manufactured, as is generally the case with neighborhood industries. The results of this treatment are set forth in Table II.

TABLE II

CHEMICAL INDUSTRIES OF THE UNITED STATES, 1880 TO 1905

	1905.	1900.	1890.	1880.
Establishments:				
Number.......	56,580	53,567	40,451	34,864
Wage earners:				
Average number	1,107,714	943,166	677,123	490,776
Wages:				
Total, ...$	575,635,257	438,404,062	305,884,278	176,227,726
Materials used:				
Cost ....$	2,933,660,817	2,215,162,767	1,247,239,582	924,573,773
Products:				
Value ....$	4,716,490,371	3,628,641,475	2,152,490,514	1,357,503,293

Table II, imperfect though it be both in the industries it includes and those it omits, gives a better conception of the actual magnitude of the industries in which chemical transformations play a part, and which are therefore really chemical industries, than Table I does and in so doing it shows the value of the products for 1905 alone to be nearly 17-fold greater than is set forth in Table I. The increase is easily accounted for by noting that items such as soap, with a product valued at over $68,000,000; glass over $79,000,000; illuminating gas over $125,000,000; dairy products over $168,000,000; refined petroleum over $175,000,000; paper and wood pulp over $188,000,000; bread and other bakery products over $269,000,000; sugar and molasses over $277,000,000; vinous, malt and distilled liquors over $340,000,000; smelting and refining of copper, lead and zinc over $461,000,000; iron and steel over $905,000,000, and many other items have been added to those embraced in Table I.

The simple enumeration of these items indicates how incomplete the statistics usually presented as those of the chemical industries are and how insufficient the popular conception of the chemical industries is. Yet even the data of Table II do not present the case in full, since all agricultural products, amounting in value in 1900 to $4,717,069,973, are really the results of chemical processes and are therefore the products of chemical industries, although not factory products.

As with Table I, so with Table II, the deductions are more readily drawn by observation of the increase and percentages of

increase for each item at the various epochs. These have therefore been ascertained and are set forth in Table III.

TABLE III

INCREASES AND PERCENTAGES OF INCREASES FOR CHEMICAL INDUSTRIES

	1900 to 1905.		1890 to 1900.		1880 to 1890.	
	Increase.	Per Cent.	Increase.	Per Cent.	Increase	Per Cent.
Establishments, number .	3,013	5.6	13,116	32.4	5,587	16.0
Wage earners, average No.	164,548	17.4	266,143	39.3	186,347	38.0
Wages	$137,231,195	31.3	$132,519,784	43.3	$129,656,552	73.6
Materials used, cost	718,498,053	32.4	967,923,182	77.7	322,665,809	34.9
Products, value.	1,087,848,896	30.0	1,476,150,961	68.6	795,987,221	58.6

Considering now the data of Table II and more particularly the increases and percentages of increase set forth for each epoch in Table III, while keeping firmly in mind the fact that we are here dealing with two 10-year periods and one 5-year period, it is again to be noted that both the actual and percentage increases in the number of establishments are the smallest of all the various increases set forth and that increase for this item for the 1900–1905 period is not only actually less than for 1890–1900 and 1880–1890, as should be expected, but is proportionately less, thus emphasizing what has been deduced from Table I as to the increased production of existing establishments.

Likewise the consideration of the data for this larger number of industries extending over a greater length of time shows that not only is the percentage increase in wages nearly as great at the census 1905 as those for cost of materials and greater than the value of products, but that, while the proportionate increase in the number of wage earners for the 1900–1905 period is less than that of 1890–1900, the proportionate gain in wages is greater. In fact, all statistics point to markedly improved conditions for the wage earner in the chemical industries, and to his increased participation in the income from the enterprise. This fact is one to be reckoned on by the chemical engineer in making up his estimate for the cost of a projected enterprise which it is proposed to install.

The statistics of Tables II and III, on the other hand, do not so markedly support the deductions drawn from Table I as to the

increase in cost of materials used when compared with the increase in the value of the products in 1900–1905. However, when we consider the larger items included in these later statistics, such as iron and steel; smelting and refining of copper, lead and zinc and others we may each of us recall a variety of labor-saving devices which have been invented and introduced for cheapening the cost of production and handling of the raw materials of these industries, and that the inventions have increased in number and perfection with the growth in magnitude of these industries.

An increase in cost of materials is in conformity with the long-recognized natural law of supply and demand. A modification of this law through which labor may get its fair share of increase and capital may get its fair share of increase while the actual cost may not proportionately be increased has been brought about in recent times through the increase in the magnitude of the unit of demand, or in other terms the quantity handled. As stated, this has to an extent been rendered possible by the introduction of labor-saving machinery, much of which has been invented in this country.

But in my opinion, and if I read aright the reports of foreign commentators on our chemical industries, in their opinions, the chief modification in the operation of this law has been made in this country through the development of "team work," though the writers style it organization or systemization.

Entering on my fortieth consecutive year of college teaching, I might, from what has been so persistently dinned into my ears, have been led to believe that "team work" originated in the minds of the college youths who flock to Franklin Field or to the Harvard Stadium. Sitting on the bleachers with practical politicians and presidents, I might be led to suppose that "team work" was an invention of the professional athlete. As a fact the idea of "team work" is a very old one and military in its essence and original application. It is embodied in our national motto. It is commemorated in the "Charge of the Light Brigade." But this older practice, while greatly promoting efficiency, demanded such unreasoning subordination that the private soldier was properly looked upon as but "food for powder," and when this system was introduced into the factory the operator became but "a cog in the machine."

The modification in this plan of "team work" which has been

developed to such advantage in the industrial plants of this country has come through a recognition of the great value of individuality and the necessity for its preservation and development, and it has been demonstrated that the higher the intelligence of the individuals who merge their entities with that of their fellows in a common purpose, and the more complete their comprehension of the means used and the end sought the more successful is the result whether gauged by the quality, or the quantity, or the cost of the output. I am happy to say that the chemist has destroyed the older military idea, even in the army, for by his invention of high-powered smokeless powder he has compelled armies to fight in open order, so that each individual must exercise his own powers in attack and defense, and be trained to take the initiative in case of necessity.

Naturally the application of labor-saving machinery and of "team work" is most readily made and yields most efficient results in the production, transportation and handling of the raw materials of our larger industries, and it is in these that we find the smaller proportionate increase in the cost of materials.

American industries, in which the chemical industries are included, have signalized themselves by the introduction of standards, by the introduction of interchangeable parts into mechanisms, by the wide application of labor-saving machinery and by the use of "team work." Yet notwithstanding the vast resources of this country, their ease of access, and the cheapening, by methods such as described, of many of the costs of production, the cost of "living," not only here but throughout the civilized world, has steadily increased, and I attribute this largely to the work of the chemist.

At St. Louis, in 1904, I said, "Technical chemistry, then, invades the domains of economics, of politics, and of diplomacy. A striking example of its effects in economies and politics is found in the settlement of the silver question. Gold is a most widely diffused metal. It has, for instance, been shown by assayers at the U. S. Mint at Philadelphia that if the gold in the clay of the bricks of which the buildings of the Quaker City are built could be brought to the surface, the fronts would all be gilded. In the past our processes for the isolation of this metal have been so costly that only the richer ores would bear treatment. Large bodies of low-grade ores which have been discovered and mountains of tailings carrying values were looked upon as worthless, while

enormous quantities of copper, lead, and other metals containing gold were sent into the market to be devoted to common uses, because the cost of separation was greater than the value of the separated products. Eight years ago, when the "silver question" was made the national issue, while the orators were declaiming from the stump, the chemists were quietly working at the problem in their laboratories and factories. Manhe's process for bessemerizing copper ores was combined with the electrolytic refining of the product, so that even traces of gold were economically recovered, while the cyanide processes, such as the MacArthur-Forrest, the Siemens-Halske, the Pelatan-Clerici, and others for the extraction and recovery of gold from low-grade ores and tailings, were successfully worked out and put into practical operation to such effect that by the cyanide processes alone gold to the value of $7,917,129 was recovered in the United States in 1902, which is more than was ever won throughout the whole world by all methods in any one year up to 1661, and probably up to 1701. The data for other purposes are not at hand for 1902, but the returns for 1900 show that gold to the value of $88,985,218 was recovered in the treatment of lead and copper ores in the United States, of which $56,566,971 worth was recovered in refining. It has but recently been publicly proclaimed in this city of St. Louis, that the "silver question" is settled, and it is settled, but it was settled largely through the efforts of the technical chemists and metallurgist."

With the improvements in methods and diminution in cost of extraction the Pactilean stream has continued to flow in steadily increasing volume* until the flood of gold has become so great that its purchasing power has become markedly reduced, and costs, measured in terms of gold, have become markedly greater. With this condition well determined the chemist has again stepped in to increase the cost of living by requiring the application of costly

* PRODUCTION OF GOLD

Year.	World's Production.		Production in the United States.	
	Fine Ounces.	Value.	Fine Ounces.	Value.
1878	5,761,114	$119,092,800	2,476,800	$51,200,000
1888	5,330,775	110,196,900	1,604,841	43,175,000
1898	13,877,806	286,879,700	3,118,398	64,463,000
1908	21,378,481	441,932,200	4,574,349	94,560,000

methods of inspection of foods, drugs and other articles of consumption; by demanding the elimination of preservatives which permitted the abundance of the harvest being kept until time of need; or the plethora of one locality being sent to the land smitten with leanness; by insisting on the introduction of expensive sanitary arrangements. Pure food laws are the vogue, and all the other needs of man are becoming the subject of special legislation, some wise, but much otherwise. It would prove an interesting exhibit if a statistician were to assemble the actual costs in the administration and execution of these laws in this country alone during the past five years.

I speak with earnestness because I have repeatedly been a participant in these movements, and am even now engaged in an analogous humanitarian enterprise, and I know that a certain result of all such endeavors to improve the lot of man is to put the community to an increased expense.

Having confessed myself, and having found my profession guilty, as charged, I now assert that a chief duty of our profession is to determine methods by which the income may be increased or the costs of living in the land decreased, or preferably both, and I urge as a first measure the advocacy of the policy of preventing any material from leaving the country until it has passed through all processes of manufacture of which it is capable. The meaning of this is evident on inspection of the Exports of Domestic Merchandise (Table IV) prepared by the U. S. Bureau of Statistics, where we find that in 1908 over 885 million dollars' worth, or 48.19 per cent of the total exports, consisted of cotton, breadstuffs, meat and dairy products, and coal, much of which had not undergone any degree of manufacture whatever. All this food should have been elaborated in this country into brain and brawn, and the coal made to yield its energy, and then should have been expended here in manufacture. We should further have put into manufactured form the raw materials of other lands.

Inspecting on the other, the table of Imports of Merchandise (Table V) prepared by the U. S. Bureau of Statistics, we find that in 1908 but a little over 210 million dollars' worth, or 17.87 per cent of our imports, consisted specifically of unmanufactured materials, such as silk, hides and skins, India rubber and gutta percha, wool, cotton, copper, lead and iron ores, and briquettes, which would properly go into manufactures here.

We sit back glorying in our country, its wide extent, its rich resources, its teeming millions of independent and self-respecting people; and yet after our fleet has circumnavigated the globe we continue to sacrifice the fertility of our soils to the support of older civilizations and remain content, while ranging ourselves with those nations that live solely on their primary resources, since the "balance of trade" is in our favor. But we as chemists know that this condition cannot last. We know that the average fertility of our soil has been growing steadily less and that only by following sound scientific practice can the fertility of the impoverished soil be restored.

The utilization of the soil as a chemical factory is but one of the problems with which the chemist has to deal. That which appeals most nearly to us as chemical engineers is the item that appears as second in magnitude in the Table of Imports of Merchandise and which has held this second place for years, namely "Chemicals, drugs and dyes," for this category embraces those substances commonly known as chemicals, or the products of the "black art." In 1908 we imported $73,237,033 worth of this class of materials, or 6.13 per cent of our total imports. While we exported but $20,873,155 worth, or 1.14 per cent of our total exports. There was therefore a balance of $52,363,878 against us in this item in which the chemical engineers of this country are most nearly concerned. It is true that among these imports are upwards of $15,000,000 worth of crude drugs and dyewoods, and quantities of other crude material, but there are many million dollars' worth of substances included here that should have been manufactured in this country. Attention need only to be called to the acids imported to a value of over $1,300,000 to emphasize this fact, for while we are seeking an outlet for our sawdust, we find in this list nearly 9,000,000 pounds of oxalic acid. Or attention might be called to the more than $7,000,000 worth of coal-tar products and preparations, not medicinal. Had this been accomplished there is little doubt that our exports of such substances would also have been large. And what is true of the industries commonly called chemical would equally apply to those larger chemical industries not included in the common category.

Another policy we should follow is the promotion of chemical manufactures throughout a larger portion of our great territory. For this purpose, I have prepared Table VI, showing by states the

TABLE IV

VALUES OF EXPORTS OF DOMESTIC MERCHANDISE, BY PRINCIPAL ARTICLES AND CLASSES, IN ORDER OF MAGNITUDE IN 1908, DURING THE YEARS ENDING JUNE 30, 1902–1908

Order of Magnitude, 1908.	Articles.	1902	1903	1904	1905	1906	1907	1908 Value.	1908 Per Cent of Total.
		Dollars.	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	
1	Cotton, unmanufactured	290,651,819	316,180,429	370,811,246	379,965,014	401,005,921	481,277,797	437,788,202	23.86
2	Breadstuffs	213,134,344	221,242,285	149,050,378	107,732,910	186,468,901	184,120,702	215,260,588	11.73
3	Meat and dairy products	199,861,378	179,839,714	176,027,586	169,998,873	210,990,065	202,392,508	192,802,708	10.51
4	Iron and steel, and manufactures of	98,552,562	96,642,467	111,948,586	134,728,363	160,984,985	181,530,871	183,982,182	10.03
5	Copper, and manufactures of	43,820,070	40,594,613	58,119,006	87,564,009	83,178,635	96,600,698	105,872,711	5.77
6	Mineral oils	72,302,822	67,253,533	79,060,469	79,793,222	84,241,327	84,855,715	104,116,440	5.67
7	Wood, and manufactures of	47,779,848	57,743,535	65,428,417	58,002,977	69,080,394	83,349,575	81,521,305	4.44
8	Leather, and manufactures of	29,798,323	31,617,389	33,980,615	37,936,745	40,642,858	45,476,969	40,688,619	2.22
9	Tobacco, and manufactures of	32,772,849	40,444,689	34,683,531	35,491,019	34,218,847	39,113,011	39,463,679	2.15
10	Coal	20,765,461	21,206,498	27,820,323	29,158,322	28,216,376	34,727,762	39,355,759	2.15
11	Animals	44,871,684	34,781,193	47,977,875	46,728,281	49,139,568	41,203,080	34,101,289	1.86
12	Cotton, manufactures of	32,108,362	32,216,304	22,403,713	49,666,080	52,944,033	32,305,412	25,177,758	1.37
13	Agricultural implements	16,286,740	21,006,622	22,749,635	20,721,741	24,554,427	26,936,456	24,344,398	1.33
14	Cars, carriages, etc	9,872,516	10,499,195	10,936,618	10,610,437	17,788,425	20,513,407	22,072,902	1.20
15	Naval stores	11,733,562	12,918,708	16,145,222	16,106,643	20,075,585	21,686,752	21,641,599	1.18
16	Oil cake and oil-cake meal *	19,779,142	19,743,711	16,899,257	21,498,085	23,386,218	25,738,471	21,064,974	1.15
17	Chemicals, drugs, dyes, and medicines	13,626,837	14,150,493	15,065,682	16,595,523	19,155,989	20,373,036	20,873,155	1.14
18	Vegetable oil	15,308,633	16,234,362	12,618,381	16,632,232	15,906,031	19,550,514	19,633,967	1.07
19	Fruits and nuts	8,719,344	18,057,677	20,678,665	15,606,586	15,274,158	17,588,432	14,338,864	0.78
20	Instruments for scientific purposes	5,389,476	7,130,508	8,297,723	8,172,980	10,887,774	13,661,455	11,578,010	0.63
21	Fertilizers.	6,256,035	6,724,301	7,112,512	7,620,886	8,686,965	8,596,711	10,970,931	0.59
22	Paraffin and paraffin wax	8,858,844	9,411,294	8,859,964	7,789,160	8,808,245	9,030,992	8,740,929	0.48
23	Seeds	8,027,824	9,455,283	2,583,325	2,557,747	8,912,662	10,094,609	8,683,688	0.47
24	Paper, and manufactures of	7,312,030	7,180,014	7,543,728	8,238,088	9,536,065	9,856,733	8,064,706	0.44

25	Furs and fur skins	5,030,204	6,181,115	5,422,945	6,599,222	8,002,282	7,139,221	7,712,890	0.42
26	India rubber, manufactures of	4,032,100	4,675,157	5,148,950	5,508,664	6,543,735	7,428,714	7,573,570	0.41
27	Fibers, vegetable, etc., manufactures of	4,575,219	5,290,948	6,414,636	6,766,809	8,157,211	8,308,112	7,225,798	0.39
28	Books, maps, engravings, etc.	3,997,977	4,442,653	4,347,304	4,844,160	5,839,452	5,813,107	6,107,053	0.33
29	Grease, grease scraps, etc.	2,610,925	2,926,565	3,311,777	3,710,907	4,138,333	5,473,623	5,762,709	0.31
30	Fish	6,563,199	6,717,274	7,857,041	6,527,863	7,559,178	5,536,856	5,685,916	0.31
31	Household and personal effects	2,570,369	2,652,787	2,615,076	3,146,969	3,595,128	3,928,946	4,782,436	0.26
32	Coffee, green	3,209,946	3,295,968	3,656,943	1,966,107	3,483,238	4,692,137	4,314,020	0.24
33	Sugar, molasses, and confectionery	3,237,329	3,104,653	3,522,805	4,131,707	4,526,334	3,973,360	4,068,357	0.22
34	Paints, pigments, and colors	2,096,379	2,350,937	2,756,581	3,126,317	3,773,064	3,931,899	4,001,824	0.22
35	Vegetables	2,546,287	2,543,488	2,603,374	3,200,860	3,567,127	4,007,833	3,895,294	0.21
36	Explosives	2,062,381	2,454,510	2,441,596	2,559,837	3,568,038	4,082,402	3,705,517	0.20
37	Brass, and manufactures of	1,930,810	2,000,432	2,557,484	3,025,764	3,474,981	4,580,455	3,701,871	0.20
38	Soap	1,630,938	2,452,777	2,499,933	2,670,231	2,781,179	3,806,097	3,407,220	0.19
39	Musical instruments	3,694,143	3,381,509	3,230,982	3,144,787	3,168,052	3,256,063	3,371,521	0.18
40	Hops	1,550,657	1,909,951	2,116,180	4,480,666	3,125,843	3,531,772	2,963,167	0.16
41	Nickel, nickel oxide, and matte	1,190,606	864,221	940,558	3,196,622	3,240,544	3,218,862	2,948,058	0.16
42	Clocks and watches, and parts of	2,144,490	2,133,529	2,281,195	2,316,414	2,598,441	3,169,272	2,848,725	0.16
43	Coke	1,720,457	1,912,459	2,223,233	2,228,442	2,435,604	3,013,088	2,718,385	0.15
44	Glucose and grape sugar	2,319,286	2,460,022	2,949,545	3,206,794	3,489,192	3,017,527	2,540,640	0.14
45	Glass and glassware	1,960,106	2,150,699	1,978,481	2,252,799	2,433,904	2,604,717	2,505,417	0.14
46	Wool, manufactures of	1,512,457	1,722,128	1,987,938	2,035,054	2,119,518	2,239,106	2,219,815	0.12
47	Lamps, chandeliers, etc.	963,638	1,133,290	1,502,888	1,579,125	1,954,091	1,875,869	1,827,216	0.10
48	Spirits, distilled	2,673,273	1,990,091	1,691,467	1,968,767	1,525,225	1,827,757	1,816,287	0.10
49	Zinc, and manufactures of	2,017,191	2,346,629	1,710,211	3,085,245	2,780,199	2,143,574	1,606,032	0.09
50	Hay	2,580,622	828,483	1,052,705	1,089,505	1,116,307	976,287	1,463,010	0.08
51	Marble, stone, and manufactures of	1,761,696	1,465,244	1,589,790	1,283,219	1,466,561	1,433,123	1,248,996	0.07
52	Starch	656,705	832,943	1,340,282	1,430,572	1,490,797	1,126,465	1,142,054	0.06
53	Malt liquors	1,290,062	1,178,740	854,119	1,012,808	1,116,776	1,215,340	1,020,172	0.06
	All other articles	23,761,904	22,557,283	25,770,532	30,732,482	30,998,594	35,784,782	38,463,024	2.10
	Total	1,355,481,861	1,392,231,302	1,435,179,017	1,491,744,641	1,717,953,382	1,853,718,034	1,834,786,357	100.00

* Corn oil cake not included.

TABLE V

IMPORTS OF MERCHANDISE, BY PRINCIPAL ARTICLES AND CLASSES, YEARS ENDING JUNE 30, 1902–1908

Order of Magnitude, 1908.	ARTICLES.	1902	1903	1904	1905	1906	1907	1908 Value.	1908 Per Cent of Total.
		Dollars.	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	*Dollars.*	
1	Sugar	55,061,097	72,088,973	71,915,753	97,645,449	85,460,088	92,806,253	80,258,147	6.72
2	Chemicals, drugs, and dyes	57,723,622	64,351,199	65,294,558	64,779,559	74,477,137	82,997,914	73,237,033	6.13
3	Cotton, manufactures of	44,460,126	52,462,755	49,524,246	48,919,936	63,043,322	73,704,636	68,379,781	5.72
4	Coffee	70,982,155	59,200,749	69,551,799	84,654,062	73,256,134	78,231,902	67,688,106	5.67
5	Silk, unmanufactured	42,635,351	50,011,050	46,100,500	61,040,053	54,080,504	71,411,899	64,546,903	5.40
6	Hides and skins	58,011,168	58,031,613	52,006,070	64,764,146	83,882,167	83,206,545	54,770,136	4.59
7	Fibers, vegetable, etc., manufactures of	39,036,364	39,334,521	40,308,837	40,125,406	51,437,581	67,422,557	54,467,572	4.56
8	Wood, and manufactures of	24,445,599	28,746,271	26,984,353	29,564,323	36,532,706	42,969,941	43,527,982	3.64
9	India rubber and gutta-percha, crude	25,652,977	31,004,541	41,049,434	50,729,873	46,035,685	60,206,418	37,753,266	3.16
10	Fruits and nuts	21,480,525	23,726,636	24,435,854	25,937,456	28,915,747	35,867,160	37,354,742	3.13
11	Fibers, vegetable, etc, unmanufactured	31,545,962	34,462,513	37,814,285	38,118,071	39,360,290	42,239,358	35,493,083	2.97
12	Silk, manufactures of	32,640,242	35,963,552	31,973,680	32,614,540	32,910,590	38,653,251	32,717,668	2.74
13	Iron and steel, manufactures of	27,180,247	51,617,312	27,028,312	23,510,164	29,053,987	40,587,865	27,607,909	2.31
14	Tobacco, and manufactures of	17,706,493	20,579,120	20,073,346	22,145,846	26,590,706	30,192,375	27,267,913	2.28
15	Tin, in bars, blocks, and pigs	19,461,850	23,618,802	21,486,311	23,378,471	30,932,998	38,117,459	25,295,061	2.12
16	Copper, manufactures of	10,968,948	17,505,247	18,215,442	19,942,511	25,835,502	39,428,687	24,462,663	2.05
17	Wool, unmanufactured	17,711,788	22,152,961	24,813,591	46,225,558	39,068,372	41,534,028	23,664,938	1.98
18	Spirits, wines, and malt liquors	15,246,640	17,171,617	16,662,702	17,652,323	19,257,590	22,104,235	20,771,804	1.74
19	Wool, manufactures of	17,384,463	19,546,385	17,733,788	17,893,663	23,080,683	22,321,460	19,387,978	1.62
20	Oils	9,300,198	12,283,957	11,179,442	11,593,520	13,723,948	17,068,777	18,292,393	1.53
21	Furs, and manufactures of	15,623,601	15,301,912	14,763,002	18,306,302	21,855,682	21,884,034	15,918,149	1.33
22	Diamonds and other precious stones.	23,348,225	31,479,223	22,964,119	33,313,931	40,247,010	42,278,901	16,642,634	1.39
23	Articles, the growth, etc., of the United States, returned	5,815,628	7,170,573	9,899,470	9,079,124	11,134,912	11,833,983	16,599,766	1.39
24	Tea	9,390,128	15,659,229	18,229,310	16,230,858	14,580,878	13,915,544	16,309,870	1.37
25	Cocoa, crude, and leaves and shells of	6,656,504	7,820,087	8,873,709	8,577,649	8,697,515	13,376,562	14,257,250	1.19

26	Cotton, unmanufactured	11,712,170	10,892,591	8,541,510	9,414,750	10,879,592	19,930,988	14,172,241	1.19
27	Leather, and manufactures of	11,317,785	11,294,167	11,100,215	11,666,233	15,140,926	20,393,533	14,127,347	1.18
28	Earthen, stone, and china ware	9,680,156	10,512,052	12,005,014	11,659,723	12,877,528	13,706,790	13,427,969	1.12
29	Fish	8,527,097	8,635,583	9,889,697	10,498,076	11,607,602	12,335,988	12,292,770	1.03
30	Paper, and manufactures of	4,223,125	4,733,036	5,319,086	5,623,638	6,998,761	10,727,885	12,223,058	1.02
31	Meat and dairy products	3,510,696	4,703,536	4,197,466	4,253,414	5,117,054	6,768,432	8,877,183	0.74
32	Vegetables	7,039,835	4,581,355	7,008,602	3,983,272	5,092,932	5,728,472	8,289,068	0.69
33	Toys	4,023,670	4,232,074	4,977,389	4,964,457	5,887,863	6,993,561	7,206,423	0.60
34	Breadstuffs	2,580,295	3,023,160	3,247,503	6,557,347	4,513,667	5,892,968	7,138,214	0.60
35	Copper ore	14,003,840	3,385,524	3,466,381	4,892,961	6,727,861	8,296,328	7,057,080	0.59
36	Metal, and manufactures of, not elsewhere specified	6,223,383	7,057,202	7,092,125	7,050,118	7,888,565	10,325,446	6,768,637	0.57
37	Glass and glassware	6,205,052	7,255,879	6,583,168	5,948,839	7,507,823	7,596,631	6,570,123	0.55
38	Seeds	3,252,152	2,831,279	3,587,469	3,457,619	5,388,043	6,404,776	6,371,470	0.53
39	Books, maps, engravings, and other printed matter	4,133,215	4,323,938	4,529,187	4,589,858	5,599,948	6,451,309	6,036,693	0.51
40	Coal, bituminous	5,310,450	10,562,185	5,043,824	3,713,748	4,367,750	4,184,541	5,123,862	0.43
41	Fertilizers	2,426,758	3,100,276	3,503,726	4,524,700	4,446,360	5,341,430	4,970,461	0.42
42	Hats, bonnets, and hoods, and materials for	3,050,478	3,871,278	3,963,043	4,379,473	4,571,184	6,820,259	4,852,548	0.41
43	Rice	2,926,921	3,061,473	3,073,430	2,010,966	3,082,203	4,392,146	4,798,553	0.40
44	Animals	4,624,531	4,533,845	3,129,609	3,337,454	3,914,382	4,344,282	4,777,459	0.40
45	Household and personal effects	2,934,244	2,856,007	3,040,523	3,263,384	3,941,875	3,835,354	4,446,187	0.37
46	Feathers and down, crude, not dressed, etc	2,032,566	2,476,659	2,742,018	2,036,791	2,970,260	4,401,131	4,360,721	0.37
47	Matting for floors, etc.	3,817,866	3,780,050	3,609,795	3,600,088	3,831,436	3,769,202	4,333,044	0.36
48	Art works	3,516,536	4,310,315	3,286,262	4,381,324	4,908,782	5,867,265	4,310,767	0.36
49	Cork wood, or cork bark, and manufactures of	2,464,934	2,567,580	2,295,138	2,738,319	3,313,306	4,063,982	4,249,006	0.36
50	Lead, in ore	4,497,360	4,073,099	3,374,661	3,616,476	3,534,876	3,352,534	4,147,720	0.35
51	Paper stock, crude	2,770,255	3,015,084	2,900,713	3,796,595	4,374,464	5,580,528	3,675,926	0.31
52	Spices	3,685,242	4,815,125	4,366,008	4,583,356	5,188,116	5,113,000	3,591,537	0.30
53	Hair, and manufactures of	2,055,536	2,775,084	2,727,062	3,428,404	3,854,349	3,604,599	3,561,012	0.30
54	Iron ore	2,362,544	2,351,278	1,593,279	1,670,683	2,728,854	3,360,449	2,949,462	0.25
55	Clocks and watches, and parts of	2,460,324	2,672,310	2,990,474	2,966,495	3,105,036	3,593,173	2,922,142	0.25
56	Cement	1,478,452	3,607,666	2,052,952	1,355,696	1,394,447	3,778,114	2,100,598	0.18
57	Bristles	2,047,331	2,654,604	2,367,301	2,370,498	2,695,746	3,261,877	2,097,777	0.18
58	Jewelry, and manufactures of gold and silver	2,642,345	2,007,433	2,048,821	1,303,652	1,739,953	1,779,527	1,672,275	0.14
	All other articles	50,313,903	57,875,712	52,552,007	57,131,870	73,919,068	88,063,181	74,169,712	6.21
	Total	903,320,948	1,025,719,237	991,087,371	1,117,513,071	1,226,562,446	1,434,421,425	1,194,341,792	100.00

locations of each of the 1786 establishments reported for Chemicals and Allied Products at the census of 1905, and I find that seven states or territories, viz., Arkansas, Idaho, Montana, New Mexico, North Dakato, South Dakota and Utah did not at that time possess a single establishment devoted to any of the large number of industries embraced in Chemicals and Allied Products. Oklahoma, New Hampshire and Wyoming each possessed but one, and the District of Columbia, Nebraska, Nevada, Oregon, Texas and Vermont each less than five.

TABLE VI

NUMBER OF ACTIVE ESTABLISHMENTS FOR CHEMICALS AND ALLIED PRODUCTS, BY STATES, 1905

	1905		1905
Alabama	27	Mississippi	7
Alaska	1	Missouri	47
Arizona	....	Nebraska	4
California	63	Nevada	3
Colorado	6	New Hampshire	1
Connecticut	40	New Jersey	144
Delaware	13	New York	264
District of Columbia	3	North Carolina	42
Florida	15	Ohio	128
Georgia	75	Oregon	4
Illinois	89	Pennsylvania	315
Indiana	52	Rhode Island	17
Indian Territory	1	South Carolina	26
Iowa	6	Tennessee	22
Kansas	10	Texas	3
Kentucky	21	Vermont	3
Louisiana	12	Virginia	62
Maine	9	Washington	9
Maryland	58	West Virginia	25
Massachusetts	77	Wisconsin	19
Michigan	52	Wyoming	1
Minnesota	10		

In order to bring this matter of the distribution of the industries manufacturing Chemical and Allied Products more clearly to your attention I have, through the courtesy of the Director of the Bureau of the Census, had prepared a map of the United States showing the location of the establishments, both principal and

subsidiary, manufacturing sulphuric acid, those making explosives, and those engaged in wood distillation, each being a typical industry, and the sulphuric acid industry being generally accepted as of fundamental importance.

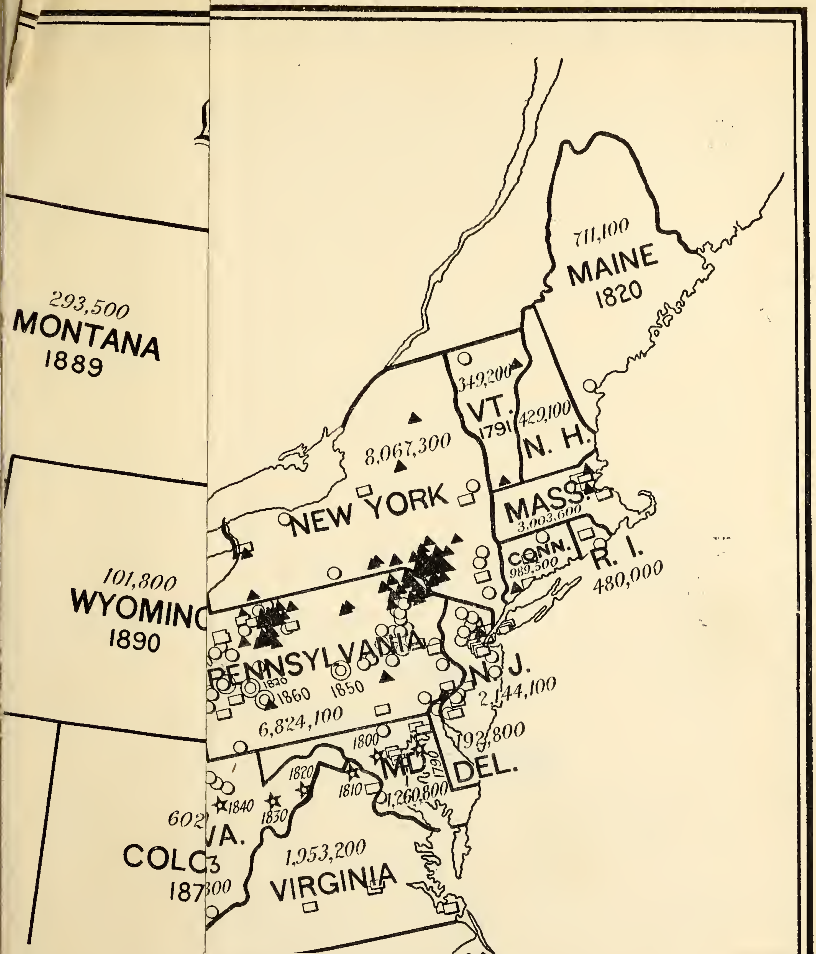
From this chart it appears that 13 states and territories, being the 7 already named (Arkansas, Idaho, Montana, New Mexico, North Dakota, South Dakota, Utah) with Iowa, Nebraska, New Hampshire, Nevada, Oregon, and Wyoming, containing 7,648,000 out of the 76,303,387 inhabitants of the Continental United States in 1905, or over 10 per cent of the whole, did not possess a single establishment devoted to any one of these industries.

Considering sulphuric acid only, which is so important an industry that it has frequently been referred to as an index of the state of civilization of a people, we find that 23 states and territories, namely the 13 just enumerated, together with Delaware, District of Columbia, Kentucky, Maine, Minnesota, Missouri, Oklahoma, Washington and West Virginia, containing 19,562,200 population, or 25.6 per cent of the total, did not possess a single sulphuric acid plant within their borders.

Turning now to the East, we find that 11 out of the 13 original colonies, viz., Connecticut, Georgia, Maryland, Massachusetts, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina and Virginia, contained 30,695,000 population, or 40.2 per cent of the total, and 100 sulphuric acid factories, or 67.1 per cent of the total number existing in the country. Analysis of the statistics of the separate states shows that the number of these establishments does not follow the population, Georgia, for instance, with about one-fourth the population of New York, having twice the number of sulphuric acid factories that New York had.

I am aware that the number of establishments in an industry, is an unsafe criterion as to the magnitude or importance of that industry, but this feature has been chosen as lending itself most easily to graphic demonstration. I have therefore assembled, by geographic divisions, in Table VII, data for the quantity of sulphuric acid produced, and we find that inspection of this leads to much the same result as to that which was drawn from the consideration of the distribution of the establishments.

All investigations show that there is an enormous extent of fairly well-populated area in this country yet awaiting develop-



293,500
MONTANA
1889
101,800
1890
711,100
MAINE
1820
349,200
VT.
1791
429,100
N. H.
8,067,300
NEW YORK
MASS.
3,003,600
CONN.
989,500
R. I.
480,000
PENNSYLVANIA
1870
1860
1850
6,824,100
N. J.
2,144,100
192,800
DEL.
1800
1790
MD
1,260,800
1820
1810
1840
1830
1,953,200
VIRGINIA

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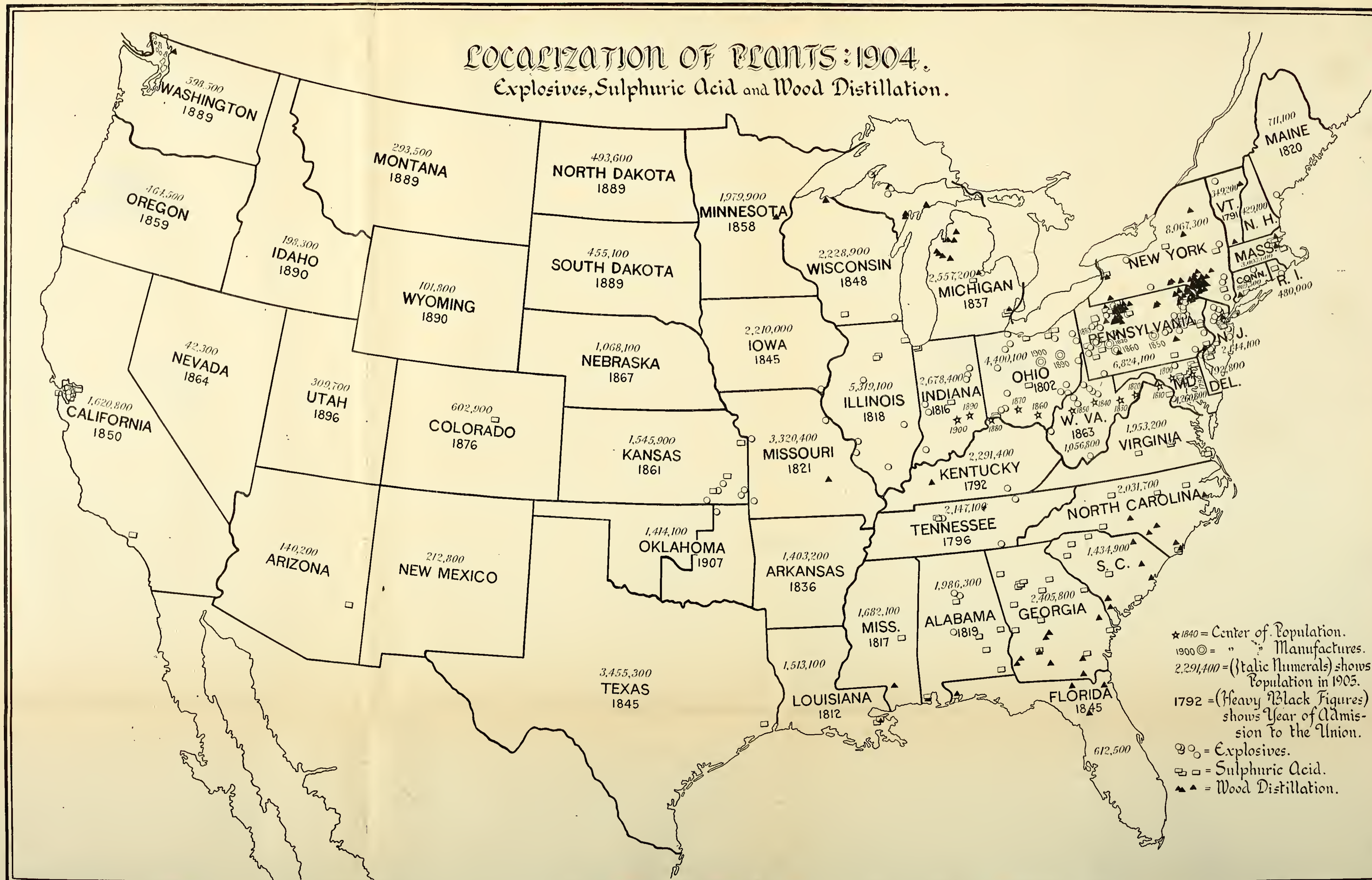
LOCALIZATION OF PLANTS: 1904.
Explosives, Sulphuric Acid and Wood Distillation.
398,500 WASHINGTON 1889
464,500 OREGON 1859
1,620,800 CALIFORNIA 1850
293,500 MONTANA 1889
198,300 IDAHO 1890
42,300 NEVADA 1864
309,700 UTAH 1896
101,800 WYOMING 1890
602,900 COLORADO 1876
140,200 ARIZONA
212,800 NEW MEXICO
493,600 NORTH DAKOTA 1889
455,100 SOUTH DAKOTA 1889
1,068,100 NEBRASKA 1867
1,545,900 KANSAS 1861
1,414,100 OKLAHOMA 1907
3,455,300 TEXAS 1845
1,979,900 MINNESOTA 1858
2,210,000 IOWA 1845
3,320,400 MISSOURI 1821
1,403,200 ARKANSAS 1836
1,513,100 LOUISIANA 1812
2,228,900 WISCONSIN 1848
5,319,100 ILLINOIS 1818
2,557,200 MICHIGAN 1837
2,678,400 INDIANA 1816
4,400,100 OHIO 1802
2,291,400 KENTUCKY 1792
2,147,100 TENNESSEE 1796
1,682,100 MISS. 1817
1,986,300 ALABAMA 1819
2,405,800 GEORGIA
612,500 FLORIDA 1845
1,434,900 S. C.
2,031,700 NORTH CAROLINA
1,953,200 VIRGINIA
W. VA. 1863 1,056,800
6,824,100 PENNSYLVANIA
8,067,300 NEW YORK
N. J. 2,144,100
MD. 1,260,800
DEL.
349,200 VT. 1791
429,100 N. H.
711,100 MAINE 1820
MASS.
CONN.
R. I. 480,000
1840 = Center of Population.
1900 = " " Manufactures.
2,291,400 = (Italic Numerals) shows Population in 1905.
1792 = (Heavy Black Figures) shows Year of Admission to the Union.
= Explosives.
= Sulphuric Acid.
= Wood Distillation.

ment by the chemical engineer, and I commend this field of service to your attention.

TABLE VII

QUANTITY OF SULPHURIC ACID PRODUCED IN THE UNITED STATES BY GEOGRAPHIC DIVISIONS: 1905 AND 1900

Division.	1905.	1900.
	Tons.	*Tons.*
United States	1,869,437	1,548,123
North Atlantic	768,647	734,669
South Atlantic	540,593	520,575
North Central	349,906	153,979
South Central	141,107	87,665
Western	69,184	51,235

As a field in which costs may be diminished, attention may be called to the saving of waste. So much has been said on this subject that I hesitate to dwell upon it lest I weary you. But I venture to suggest that one remedy for waste, which has not been so markedly dwelt upon as it deserves, is by a change in location, and I take as an example of this the gas industry.

I have long looked upon our present custom of transporting coal long distances to be converted into gas as uneconomic, for a not inconsiderable quantity of coal is burned to provide the energy with which to haul this coal. Not only that but, since the gas constitutes but a very small percentage by weight of the coal, there is a considerable waste in hauling the coke, with its ash, and the by-products. Further, to provide for emergencies, large stocks of coal must be accumulated in advance at the gas works, and as coal, particularly gas coal, begins to deteriorate as soon as it is removed from the mine, there is a very considerable loss going on all the time from this cause. Further, as the by-products or residuals are now purchased in the crude state in relatively small quantities at the different gas works, a large part of their value is consumed in collecting and transporting them to central refineries.

By producing the gas at the mine and shipping it by pipe line the cost of haulage in the coke, with its ash, and crude by-products is saved. The wastage of coal by weathering is saved. The cost of collection and transportation of the crude residuals is saved.

Such coke as is not needed for industrial purposes can be converted in producers into gas which, by means of internal-combustion engines, can be used in generating electricity for distribution, and the ash from this coal can be put into the mine for use as a filler in place of coal.

It is evident that gas can, under these circumstances, be made and delivered at a much less cost than is the case at present, though it may be necessary after long travel to enrich it near the point of consumption. Furthermore the valuable areas now occupied by gas plants in our cities can be given up to more concentrated industries and cheap country lands be substituted for them.

I venture further to suggest that frequently an urgent reason for saving waste is to suppress a nuisance, for I do not hesitate to assert that the existence of a public nuisance is evidence of the existence of an economic waste.

Almost at the outset of my professional life, in 1872, I became involved in the famous Miller's River Nuisance case and it fell to my lot, to examine, on behalf of the citizens of Cambridge, Mass., the large slaughtering houses which were believed to be the cause of the nuisance, and to study the operations going on within them. The conditions were very complex and there were a variety of causes which led to the creation and maintenance of this most horrible and most extensive nuisance, but among other causes I found that the slaughtering houses had permitted much valuable blood and offal to escape into the stream and that, at that time, one establishment alone was pouring into the river, in the water in which it had steamed its hogs, over five tons of gelatinous matter per week, and this was done in ignorance of the existence of this matter in tank waters.

What I have found to be true regarding matter, I have also found to be true as regards energy, and I cite as an example, the nuisance of "cannonading" in blasting, which is proof in itself of the use of unnecessarily excessive charges of explosives.

But in urging the abating of a nuisance or advising the saving of waste or the conserving of resources, we should not fail to point out that it can usually be accomplished only with added expense, and that a profit can rarely be realized unless the operations are carried out on a quite considerable scale. In fact, it seems to be an economic law that only the rich can really save; that "to him that hath shall be given"; for the poor must pay the price of much

subdivision and the consequent cost of much handling and a multiplicity of containers.

In fact, we should make it plain that the advocacy of the saving of waste in manufacture and of conserving our resources necessarily implies the use of great aggregations of capital and the carrying on of large scale operations under a single management. It means the application of methods such as have been applied with great success in the manufacture of hog products, or in the refining of petroleum. In dealing with coke at the census of 1905, I found that of the 37,376,251 tons of coal coked in the United States in that census year, only 3,317,585 tons, or 8.9 per cent, were coked in by-product ovens, and I estimated from the yields and values of the by-products which were recovered that had all the coal been coked in by-product ovens there was a possible saving of $37,492,-136.* This is an enormous amount to save in a single industry in a single year, and if the saving could be made an accomplished fact it would go far toward wiping out that humiliating account against us in our imports of "Chemicals, drugs and dyes." But I have never failed to recognize the fact that this could only be accomplished by those controlling large capital, and that it meant the "killing off" of a large number of minor establishments, and I have further recognized the fact that the apparent savings set forth could not be realized until the charges against the more costly plant had been satisfied, nor until the market had been so readjusted that it could absorb this greatly increased output of by-products.

As an example of the commercial advantage resulting from the abating of a nuisance, I cite the instance of Ducktown, Tenn., whose smelters have for decades been notorious offenders. I will not repeat to you the details by which their devastating sulphurous fumes have been converted into valuable merchandise, since they have been so well set forth in current literature, but will simply note, that, by report, this saving has resulted in the suspension of a number of the sulphuric acid works in the contiguous region, and I am ready to believe this report to be true, for I look upon this result as a natural consequence of the operation of a wholesome law in economics.

However, all of the endeavors avail but little so long as we remain a dependent nation, which the quantity of manufactured "Chem-

* Bull. 65, U. S. Census of Manufactures, 1905, p. 18.

icals, drugs and dyes" imported by us indicates that we are, and especially while we import over $7,000,000 worth of coal-tar products and nearly $2,000,000 worth of ammonium sulphate, as we did in 1908, and yet allow $37,000,000 worth of the by-products produced in the coking of our coal to be wasted. It is evident that there is still a wide opportunity for the employment of the chemical engineer in developing our chemical industries.

I find that I have been led to devote my attention to the chemical industries of the United States when you have asked me to treat of those of America. I have, however, limited myself not because I consider our country America, but because of the limited amount of information that I have been able to secure relative to the other countries in North and South America. Such as is available for Canada is found in a paper by Dr. W. R. Lang, published in the Transactions of the Canadian Institute for 1904, from which it appears that, in 1903, salt was produced in the Dominion to the value of $334,000, and arsenic, in 1901, to the extent of 1,347,000 pounds. Sulphuric acid was produced in Quebec, Ontario, and British Columbia, but neither the number of factories, nor the extent of the output is given. However, in treating of the plant at Ontario, which produced about fifteen tons of acid per day, it is stated that imported brimstone was used as the raw material and this in the face of the fact that Canada abounds in pyrites. The wood-distillation industry flourishes in that country, the plant of the Lake Superior Power Company being, it is said, the largest retort plant in the world, but no statistics of production are supplied. Ammonia liquor was produced to the extent of 235,000 pounds of 28° Bé. strength, the larger part of it being exported. Soap was produced by some fifteen concerns employing about 2000 hands, the value of the product in 1902 being approximately $3,000,000. Glycerine was obtained from the soap lyes, one works being capable of treating 10,000,000 pounds of lye annually. Petroleum refining was carried on at Sarnia, the factory being able to treat 60,000 barrels of crude oil per month. Calcium carbide was made in two works, carborundum and graphite in one. There was a limited manufacture of fine and heavy chemicals. This about completes the tale for Canada.

My efforts to obtain information relative to the Central American and South American states have been less successful, though I have searched the literature and consulted officials from and to

these countries. "The Statistical Abstract of Foreign Countries" recently published by Mr. O. P. Austin, Chief of the U. S. Bureau of Statistics, covers the exports and imports of these countries for a decade, and it appears to be the only authoritative and detailed report concerning them, yet a painstaking search of the tables of exports for each of these Central American and South American countries shows no other chemical items than borate of lime, iodine, and nitrate of soda from Chili; charcoal from British Guiana and Argentina; fermented and distilled liquors from several of the countries, especially from the West Indian Islands; and dyestuffs and extracts from a number of states. Literature relating to the commercial resources and industrial activities of the Pan-American republics, other than the United States, is apparently quite meager, and information regarding their industrial activities appears not to have been collected either by the countries themselves or by students of commerce and industry. It does appear, however, from what information can be obtained, that the resources of these countries are in an undeveloped condition and that these countries present an almost virgin field for development by the chemical engineer.

I have myself attempted to inspire one such development, for at the outset of the undertaking of the construction of the Panama Canal by the United States, I advised that dynamite, which has been consumed in enormous quantities in the excavation work, and the manufactured "raw" materials of its manufacture, be made upon the Isthmus. The easy access to the nitrate of soda deposits of Chili, making but a brief water transportation necessary for delivery, and the existence of pyrites in great abundance in the vicinity of the Isthmus, making the production of sulphuric, and hence mixed, acids easy and simple were a few of the many advantages which would follow the adoption of this plan. But not the least would be the civilizing influence which chemical manufacture always exerts. It is unnecessary to say that up to the present, I have been unsuccessful in my endeavors to introduce chemical manufactures into the Central American states, but I trust that you, who have done me the honor to listen to me, may succeed where I have failed.

The Presidential Address, delivered at the Seventeenth General Meeting of the American Electrochemical Society, in Pittsburgh, Pa., May 5, 1910, Vice-President C. A. Doremus in the Chair.

SCIENCE AND INDUSTRY.

By Dr. Leo. Hendrik Baekeland.

The present age surpasses all previous epochs of history by the intense activity of the human race, the daring of its efforts, the magnitude of its accomplishments.

We know of periods in history where great wars, great political developments, migration, religious fervor, newly- discovered lands, or other causes, brought forth considerable changes in some nations, but never was the movement so widespread in geographical location, never were impulses operating so rapidly, nor on so extensive a scale as today.

We have not reached the end of this movement; quite on the contrary, it seems to gain in intensity as the years roll by.

While some few nations have taken the lead in certain lines of human endeavor, we know, on the other hand, that the same influences are at work, even in the most remote corners of the world. Countries which for ages have been dreaming dreams of rest, countries of which the political, intellectual, social or industrial conditions have remained practically unchanged for hundreds, nay, thousands of years, begin to awaken; willingly or unwillingly they, too, seem to undergo, albeit in a smaller degree, this all-pervading tendency of enterprise, this aggressive effort to better utilize their opportunities for material, social and intellectual betterment.

In other words, modern human dynamics have reached an intensity never witnessed before.

It looks to me as if all great feats recorded in the history of our race sink to nothingness if compared to what human activity is accomplishing every day since ignorant, arrogant, emotional, spasmodic efforts are slowly but surely giving place to methodical and persistent work based on exact scientific knowledge.

Whether the human race has been made happier by all this, I

shall not here try to decide. Happiness is a very subjective condition of mind, very difficult, if not impossible, to measure or to compare; the happiness of the child or the savage, and the happiness of the intellectually developed adult are two entirely different propositions. I believe, however, that even case-hardened pessimists ought to admit that our *opportunities for happiness* have considerably increased, even if so many people, not knowing better, continue to trample upon these very opportunities, blinded as they are by false ideals or by misguided aspirations.

True, the pessimist may point to the slums of large cities, to poverty, to vice, to unsatisfactory labor conditions, to high cost of living. But, what is all that compared to conditions in bygone ages? Where are the famines, the plagues, which not so long ago periodically devastated Europe, and which are still the scourge of some backward countries, like India, China and Russia?

Political corruption, dishonesty and greed are still too much in evidence, and there is still much room for higher ethics; on the other hand, anybody who wants to give himself the trouble to investigate real history will have to admit that the morals and conduct of life of many of the most exalted personages of the past, would fall way below the test of the plain average decent citizen of our republic to-day.

Most certainly there is still abundant necessity for improvement, and our race will improve as long as we put more pride in raising better children than in finding an excuse for our littleness or a consolation for our failures, by bragging about the supposed importance of our ancestors.

Nowhere have the changes of this century been so accentuated as in our industrial enterprises. We know, furthermore, that just such industries, where the developments have been most staggering, are exactly those which have utilized scientific knowledge to the largest extent. Wherever the engineer has been able to put into practice the secrets which the scientist has wrung from nature's laws, there also do we see results so far in advance, as compared to what formerly existed, that only a man with a dead soul fails to be stirred up to admiration and enthusiasm.

The modern engineer, in intellectual partnership with the scientist, is asserting the possibilities of our race to a degree never

dreamt of before; instead of cowing in wonder or fear like a savage before the forces of nature, instead of finding in these forces an object of superstition or terror, instead of perceiving in them merely an inspiration for literary or artistic effort, he learns the language of nature, listens to her laws, and then, strengthened by her revelations, he fulfils the mission of the elect and sets himself to the task of applying his knowledge for the benefit of the whole race.

Let me assert it emphatically: The two most powerful men of our generation are the scientist and the engineer.

Society at large is far from realizing this fact, simply for the reason that the scientist and the engineer manifest their power not as despots, nor as cruel tyrants. Their might is not put in evidence by the amount of chattel-slaves they hold in bondage, nor by the barbaric splendor of their lives; it is not marked by the devastation wrought by armies; their work does not consist in conquering and subjugating weaker nations; we do not see them glorified in painting and sculpture; we do not hear their exploits extolled in song and rhyme; no artists have had to record their triumphant homecoming, greeted as saviours and heroes, while marching over the mutilated corpses of their fallen enemies; they do not use their power to sow sorrow, death and misery, or to steal and plunder or fill the museums of a city like Paris with treasures of art taken by force from weaker nations. No, the masses are unaware of the immense power of the scientist and the engineer because both of them modestly play the role of "the servant in the house"; their unassuming life is devoted not to slaughter, destruction or coercion, but to the service of mankind. They do not build useless pyramids cemented with the sweat and blood of overabundant slaves, monuments to vainglorious despots, witnesses to the small value which was put in ancient times on human life and on human labor.

But the modern engineer applying the principles of science raises buildings far superior in size and conception to any architecture bygone ages can boast of; edifices incomparably more comfortable, more hygienic, more appropriate than anything built before. He raises these gigantic structures in as many days as it took years to build a temple.

In fact, after a few years he is ready to pull the same buildings

down, to erect better and bigger ones, in order to suit advanced conditions, and—nobody cares about the name of the architect or the engineer, nor does the builder care himself.

And why should anybody care? The dynamics of the age are producing changes at such a rapid rate that nowadays any building of whatever size it be, is begun with the feeling that before long it will have to come down to give place to new conditions. Erecting a 20-story building in a city like New York is about like putting up a temporary tent, which may suit us for a while, but has to be taken down whenever conditions, in the onward march of civilization, demand it. Palaces and other buildings which would have made the pride of older nations, are torn down now after a career of less than twenty years to make room for the development of our cities, to allow larger and better-adapted edifices to take their place, which probably in a relatively short time will follow their predecessors and be torn down in their turn, when our children begin to realize that they want streets four or five times wider than our now overcrowded thoroughfares.

The modern engineer and the scientist realize that much more enduring monuments than stone, brick, or bronze will mark the work of this period: they know that the diffusion and application of exact knowledge is shaping the destiny of future generations and will afford more lasting evidence of their efforts than temples or statues; they believe that their work will not count merely for material betterment, but that improved material opportunities created by them will bring forth better people, higher ideals, a better society.

To put it tersely, I dare say that the last hundred years, under the influence of the modern engineer and the scientist, have done more for the betterment of the race than all the art, all the civilizing efforts, all the so-called classical literature of past ages, for which some respectable people want us to have such an exaggerated reverence.

Consistent in their mission of true, powerful men and of servants of our race, the engineer and the scientist perform their work steadily but quietly; they are not appreciated by the unthinking multitude because of the fact that their modesty is usually as great as their achievements.

True, I know some of them who do not exactly "hide their light under a bushel"; but show me the most vain engineer or the most conceited scientist, and he will appear like the very picture of meekness and modesty if you will put him alongside some artists, some writers of fiction, some opera singers, or opera composers.

Let me insist on the fact that every one of our betterments in material conditions, every increase in our opportunities in life has been the entering wedge of vastly improved social, political and ethical changes.

The steamships of today, to which the armadas of yore, and the fleets of antiquity look like mere children's toys, bring distant nations, distant men, nearer together; so do the railroad, the press, the telegraph, the telephone.

Not only have time and distance been shortened by the industrial applications of science, but life has been lengthened in years, and still much more in accomplishments and in opportunities.

Improved means of communication do not only facilitate the exchange of products between far away nations, and allow them to compete in quality and price in the most remote corners of the world's market, but they enable more lasting exchanges than merely those of material commodities; we intermingle, develop, and distribute thoughts and knowledge which slowly but surely modify and perfect the political and ethical conditions of nations as well as of individuals.

Not so long ago, opportunities for travel, for education, wealth or comfort of existence, were given only to a very few; now in our modern community all these advantages have come within the reach of the multitude, and all this, thanks to our industrial developments.

Much has been said and written about the civilizing influence of the discovery of the printing press. Has it ever occurred to you that the printing press could accomplish very little if we had not invented the means for manufacturing cheap and good paper? In the same way every facility which science and engineering has endowed the world with finds itself reflected in the ever-increasing development of printed publications. For one book that was written a few centuries ago, thousand better prepared ones are published nowadays. Ancient authors had few

competitors and few readers, and the latter could afford to remember the names of their authors, and greatly exaggerate their merits, and overawe following generations with the extent of their importance, and hypnotize some of us in the belief that there are no good authors but dead authors, or ancient authors, an opinion unfortunately shared by some respectable pedagogues.

Today, when illiteracy is no longer the rule but the exception, new ideas, new conceptions are carried to all points of the globe: measured, discussed, hacked to pieces, or developed, all this with a rapidity never attained heretofore; and I believe that one of the most important causes of our rapid mental and industrial progress is due to the very swiftness with which information and knowledge penetrate the masses.

The man who nowadays would try to stem the tide of ideas, or intellectual advance, would only succeed in making himself ridiculous.

In the middle ages some devout people, not knowing better, could try to burn scientists and their books, and opposed for a while the march of progress, because there were so very few scientists and so few books to burn. But, nowadays, it would require more than all the combined blast furnaces of Pittsburgh to keep up this process of oxidation.

It helps a country like Russia very little to have some highly-developed men, some great scientists, great philosophers, as long as the multitude of the rural population remains in ignorance and lowness; as long as so many people are prevented by unsatisfactory material conditions to profit by the influence of their better fellow-men.

In a self-respecting community the benefits of modern conditions and opportunities for advancement are open for everybody and privileges of birth and class are now considered an anachronism, if not a crime against the human race. Yet few men stop to compare the conditions of modern life with those of the good olden times. An average man, who thinks himself underpaid and imagines he is living at a very modest pace, does not realize that when he is traveling in a modern railroad train, he enjoys comforts and advantages never dreamt of by the richest or most powerful men, princes or kings of scarcely a century ago; he forgets that his life is surer, that his health is better taken care

of than that of any potentate of former times; that the nation respects more permanently his rights as a citizen than was the case of prime ministers of 100 or 200 years ago; that his sons and daughters have better and surer opportunities of education and intellectual advancement than the children of kings of past centuries, that there is no beautiful thought in this world, no knowledge, which is not accessible to him and everybody who can read.

Man only considers a thing a luxury as long as his fellow-men cannot get it, never mind whether it be a bit of glass or a diamond, a bicycle or an automobile; commodities of modern life cease to be considered as luxuries as soon as they become easily accessible to everybody.

Neither should we be too much disappointed in meeting so many people who seem to be oblivious to our improved conditions as compared to those of former times. Society has been pushed ahead, against the will of the masses, by a few active, daring, restless men, who forced the others to follow; just like a herd of unthinking sheep is unwillingly driven forward by the shepherd and his dogs. Many people among whom we live have truly been prodded into progress; they may properly be called remnants of bygone times, symptoms of mental atavism of the race; they do not properly fit in our age; they have passively drifted along on the advancing stream of centuries, to be carried beyond where they properly belong, and now they constitute the ballast which impedes the dynamics of our modern generation.

It has been asserted so often by respectable people that science and industry cater only to our material welfare, and have little in common with culture, refinement or moral development; therefore I feel compelled to put special emphasis on this side of the question and to insist on the enormity of this error; on the contrary, the development of our industries, of our material prosperity, as well as the study and application of science are the surest and most immediate forerunners of higher civic ideals, of an improved society, of a better race.

A clean, well-nourished and well-housed individual, who can enjoy the comforts and advantages of modern surroundings, and leads an active, intelligent, productive, self-supporting and self-respecting life, is certainly more of a man and a credit to his race

than were some ancient saints, who lived from alms and spent their life in prayer and inaction, or who, for further edification of their followers, vowed never to change their clothes, nor wash nor shave nor comb themselves; he is more of a blessing to his fellow-men than the useless drone, who lives on the work of others and gives nothing in return but arrogant presumption, based on fortune, rank or title inherited from his father.

If this be then the age of rational industrialism, of applied science, how, then, is it that in some industries quality is going down, while prices are soaring upwards?

Here again it is a noteworthy fact that just such commodities as are produced by so-called scientific industries are sold cheaper and are of better quality than ever before, and this cheapening of price or betterment in quality is almost proportionate to the amount of scientific knowledge involved in their production. Let us take, for instance, the chemical and the electrical industries, both based almost exclusively on well-developed scientific data. In both these groups of industries the chemist or the physicist has had full sway, and the engineer has embodied their work in a practical form. Free and rational competition based on intellectual superiority has been their paramount factor of development. Competition based on artificial privileges like labor unions, tariff legislation, have played only a secondary role. While flour, meat, clothing, and houses were considerably less expensive 100 years ago than they are now, we find that acids, alkalies, salts, solvents, dyes and in general almost all chemicals are incomparably cheaper and of better quality than they were in the good olden times.

In some cases the changes are remarkable. For instance, a ton of sulphuric acid sells now at the same price as two pounds of the same article were sold about 150 years ago.

A similar cheapening can be found in many other chemicals, although their demand has immensely increased. Without going to extreme cases, we can state that there has been a steady improvement in most chemical manufacturing processes and that the public at large has had the benefit thereof. The same can be said of the electrical industry.

Compare this with industries which are still under the sway of the rule-of-thumb, which means the rule of the ignorant, or

where competition is based on political protection; you will find that just such rule-of-thumb-commodities, where science plays no role, are those for which the public has to pay the highest price in return for the poorest article. Married men may follow this assertion from butchers' bills to ladies' hats, from house rents to servant girls.

For the poor chemist it is almost an irony of fate that his science, by developing the "cyanide process," made gold cheaper and thereby reduced considerably the purchasing power of his meagre salary. In order to get square he will have to put himself now to the task of helping the engineer in the cheaper production of foodstuffs or clothing, or take a hand in such tax reforms which may bring about a reduction of rent or may lessen other economic anomalies.

Notwithstanding all our progress it is evident that we live in a transitory stage; next to enterprises and industries embodying the highest intellectual conceptions that our century can offer, we find, even in the most advanced countries, examples of conditions of affairs which seem truly an anachronism. This must have impressed many of you who have happened to visit factories or mills where ignorance and greed seemed the two dominant factors, where the class of men and women employed, not to speak of child labor, seemed to have undergone the full curse of their sordid surroundings. Such places are to be found often where the mental condition of the directors does not enable them to go beyond the conception of size and where the whole tendency has been towards more, more, more, instead of towards better, better, better.

How different is this from some of our better engineering and chemical enterprises, where everything bears the imprint of a steady effort towards progress and where employer and employed alike seems to undergo the uplifting force of intellectual aims. Such a happy condition of affairs is most likely to be encountered where the head is himself the scientific pioneer who has built up the enterprise.

Matters are not always so satisfactory where large organizations have gotten into the hand of a board of directors who know little else of the technical side of the business than that it pays

dividends, and for whom the main interesting factor is the value of the shares they own.

Whenever undertakings are ruled by such a class of men, we must not be astonished if their corporation counsel is more in evidence than their chemists or their engineers. What do they care if certain improvements in their processes might net them 5 per cent. more or mean better goods, if, on the other hand, they know that by a clever trick of law they can extract from the consuming public many times more? No wonder, then, if they have less time and less mental fitness for a principle of science or engineering involved in a new process than for a conference with "eminent law counsel." If they cannot alter nature's atomic weights, they may find a way of improving their invoice weights for the custom-house to the detriment of Uncle Sam. I might use for our industries the forceful quotation of Shakespeare in "Hamlet" about the State of Denmark, as long as corporation lawyers of reputation are paid incomparably better and their services are sought for so much more eagerly than the very best chemists or the ablest engineers.

This brings to my mind the case of a company which held a charter to supply a certain city with illuminating gas, and which, after enjoying a fortune-making monopoly for many years, found one day that special legislation had reduced the selling price of their product. Certain again of being able to upset this law, the company entered into long litigation, but, finally, after repeated efforts, had to realize that even its best lawyers could not change matters. From that moment on they began to inquire actively about better manufacturing processes. A friend of mine, who was requested to give his suggestion as to how they could improve their methods, replied as follows: "Up till now your company has been making *law*—now make *gas* and everything will come out all right."

Then again we find that, resourceful as the modern engineer or chemist is, his power is often simply a tool in the hands of ignorant but cunning men. In fact, our modern laws and society insure better reward for cunning or slyness than for true intellectuality.

The very abundance of our natural resources may be partly to blame for this condition of affairs; in other countries, like Ger-

many, with comparatively small natural means, competition shapes itself more towards technical perfection. If we want to learn how to reduce what I would call our "national waste," our German friends can give us valuable lessons. It is significant, too, that in large German engineering or chemical enterprises the board of directors is made up mostly of scientifically trained men—engineers, chemists and physicists. The entrance of the physicist in our industries has not yet become very evident, although in Germany it seems to be the rule, specially in electrical and other enterprises, to give to the physicist as much importance, and even more, than to the chemist; both of these scientific specialists leave the purely engineering problems to the qualified engineer.

The story was told to me how the head of one of the largest engineering firms in Germany won his spurs. Prices of copper were rising beyond precedent, and his merchant business associates insisted therefore that he should buy an amount of copper sufficiently large to supply them for their electric installations for several years to come. In the meantime, prices were going up faster and faster; but this did not seem to disturb the scientific director, who was eagerly following the results of some special research work, giving reliable data about transformers and high voltage transmission. As he understood the law of Ohm, he knew that pretty soon, even if copper was three times higher in price, he could use so much thinner wire and save money in the end. What he foresaw happened; the price of copper dropped suddenly, and Ohm's law triumphed over copper speculators.

All this does not take away the fact that although some industries suffer from brutal ignorance, others have sometimes been handicapped by a too one-sided scientific organization; I know of some instances, especially in Germany, where very respectable enterprises have not utilized their available opportunities to the proper extent, because their scientific managers lacked good business sense. I have seen some industrial enterprises much held back by too much red-tape and a choking amount of paper-wisdom. The most learned man without common sense or practical abilities can accomplish little except disappointments. Here is where the keen business man, with directness of purpose and good judgment will every time show his advantages.

An over-specialized man, whether he be a biologist, a physicist, a chemist, or an engineer, may lack the broadness of conception and action which characterizes truly great men of many-sided development.

Then, again, quite frequently the real field of usefulness of scientifically trained men is much misunderstood. For instance, it is a common mistake, made even by some engineers and physicians, as well as by business men, to imagine that the main work of the chemist is confined to performing chemical analysis. This conception is about as absurd as to think that the main usefulness of an electrical engineer consists in making electrical tests, or that the essential work of the merchant is bookkeeping.

Many a good chemist has been thus prevented from showing his best abilities by the sheer ignorance of those who employed him.

In the development of some of our industries nothing has played such an important role as scientific research work. To those who do not realize this, let me tell that not so long ago I had an opportunity in Philadelphia, to see that old electric machine of Benjamin Franklin, a small revolving glass globe mounted on a wooden frame; this was about as far as electricity went a century ago. Shortly afterwards I was confronted by those gigantic electric installations at Niagara Falls. To those who belittle the value of scientific research I recommend a comparison between this and Franklin's machine, a mere scientific toy, a clumsy affair, that would, at its best performance, and if the weather was not too damp, give off some small sparks; a contrivance so useless in its time and so devoid of apparent practical applications, that if someone had told to a "shrewd business man" of last century what this field kept in store for us, he would merely have shrugged his shoulders in derision. But now behold the hundreds of thousands of electrical horsepower developed in those monstrous generators of Niagara Falls, sensitive as a slender nerve, and yet running with the precision of a watch; distributing power and light to distant cities like Toronto and Syracuse; running heavy railroad trains as surely as the tiny drill of the dentist; converting ores into metals; transforming hundreds of tons of brine daily into caustic soda and bleach; changing mixtures of sand and coal into carborundum; ennobling plain coal

into graphite, or producing from coal and limestone new sources for illumination under the form of calcium carbide; or again fixing the nitrogen of the air on calcium carbide to change it into cyanamide, a most valuable synthetic fertilizer; and at every succeeding year new chemical achievements of the kind are still being brought forward by a set of tireless workers.

Let me ask a fair question to those who underestimate the value of research: Has that stupendous gap between Franklin's toy and the power companies of Niagara Falls been bridged by anything but by scientific research of the highest order?

Some of the better educated people in this country begin to understand more and more the necessity of scientific research. Not so long ago research work was only carried out in the laboratories of universities or in a few highly developed chemical or electrical companies; nowadays we find many intelligently conducted enterprises devoting a considerable annual outlay for systematic research work, where the resources of the chemist, the physicist and the biologist are used to good purpose.

Unfortunately, the scope and method of scientific research is difficult to understand for the uninitiated. Some people have only the haziest conceptions on this subject. Some manufacturers, totally unaware of the requirements involved in this work, in a half skeptical way grudingly conclude to organize a research department, sometimes as a last resort to help them through some difficulties; others do it "to be in style" and simply to imitate their more successful competitors. Frequently they engage a young man with little experience, who, outside of what he studied in the technical school or at the university, has everything to learn, and who, besides that, is usually entrusted at the very start with the most difficult problems. His salary is none too high, and his action is very much restricted; sometimes he is forbidden to study the current practical methods, or so-called "manufacturing secrets," and is thus prevented from getting acquainted with the very problems he is supposed to solve. I have seen other cases where the time of the research chemist was filled with odd jobs of every kind. After a while, when practical results are not forthcoming fast enough, the bookkeeper confronts him with the list of expenses which have been incurred by his work; naturally some comments are ready at hand how the same money spent on

a good salesman would have shown immediate results, and so forth. Things go along that way for a while, until the research department is abolished with the remark: "Research does not pay, we've tried it."

In other cases, where some results are obtained, the matter is taken out of the hands of the chemist before he has had time to fairly try and develop it on a large scale. The subject is now entrusted to the superintendent or the foreman, who seldom is a friend of the scientifically trained man, and nearly always resents anything which might diminish the prestige of "established practical experience." Like in all new processes, defects are soon shown, and in the natural order of things repeated failures and renewed trials on a practical scale are required before there is any possibility of regular utilization. The research chemist is allowed very little intervention at this stage of the work, and after remarks are heard how imperfect the whole thing was "before so-and-so, the practical man, had his say." Finally, initial expenses are charged against the research department, and profits credited to the "practical man."

A research department is a very difficult thing to organize and to run. It is not enough to provide a building and the necessary appliances; it is not enough to provide typewriters, card-indexing systems and office force, and all the red-tape connected with it; it is not sufficient to engage one or more well-behaved university- or college-graduates, with the necessary helpers, and to let them work under an orderly, business-like manager. You might as well try to produce masterly paintings by installing an office management and a well-organized paint and brush department, and a library containing all that has been written on the art of painting next to a splendidly-equipped studio, and then leave out the real artist who will do the painting. Nay, the most important, the almost exclusive factor in a successful research laboratory is the research chemist himself. If he is not a man who has a soul alive with his subject, if he is not enthusiastically imbued with his opportunities, if he is not qualified for his task not only by scientific training but specially by a natural gift of discrimination between what is most important in a problem and what is secondary to it, you might as well fill a hall with the marble

statues of Greek poets and imagine that they will write poetry for you.

Then if you find the man who has all the true qualifications, you may still paralyze his action by too much red-tape, too much interference in his work. A good research chemist will do more and better work with pots and pans from the "ten-cent store" in a shed or in a barn, where he is his own master, than in a splendidly-equipped laboratory where he gets irritated and interfered with by others who do not understand him.

I sometimes doubted whether it was really worth while for a young man to take up research work single handed, when so many people with abundant facilities were at work. What show, for instance, does an organic chemist have in studying a problem for which, in Germany, some large chemical companies employ hundreds of research chemists? To this I can answer that some of the most striking examples of successful research were the result of privately conducted work with modest means; in fact, I know of several instances where a research chemist who had created himself a reputation by work carried out privately under adverse circumstances showed disappointing results as soon as he became part of a vast organization. Even if you have the best-qualified research chemists, do not expect immediate results. Do not forget that problems appearing most simple require considerable time before they are thoroughly studied. Even in successful cases it may easily require many many years before a subject is so thoroughly elucidated that it can be taken up in practice.

Research is what gives a young man of strong individuality a chance to compete with those big industrial consolidations, the trusts, who, like elephants, look more imposing by their size than by their agility or perfection, and who, like that pachyderm, have many vulnerable spots, and are just as much handicapped by their lack of flexibility and by their ponderosity. Some steel manufacturers may be unable to think about anything but tonnage, and yet the work of some chemists has already indicated that the quality of steel of the future, or of its alloys, may be improved to such a degree that probably the average steel of today will look to our children as brittle and imperfect as pig-iron appears to us. Neither should we lose sight of the fact that even

to the most exclusive mechanical enterprises there is a chemical side, although the importance of the latter may not be apparent to the man who is not a chemist.

Let me give also a warning to such manufacturers who try to secure only by uncompromising secrecy the money-making end of their industries.

As far as my experience goes, exaggerated secrecy is very often an indication of lack of knowledge, of industrial feebleness and incompetency; a miser is most of the time a man of small means.

If chemists had been holding their results from each other we would still be in the dark ages of the alchemist. No secrecy, however jealously carried out, can outweigh enlightened research work protected by wise patent legislation. If our patent laws do not protect enough, then our prime duty becomes to change them until they answer their purpose as defined by the Constitution of the United States. The care with which patent laws are administered is a direct measure of the industrial importance of a country. Piracy cannot flourish, either on the seas or in intellectual property, if ethics of justice and equity can be made to prevail.

Every recorded success of the scientist or the engineer is an additional evidence that ignorant greed and brutal rapacity cannot forever have full sway in this world, and that the rule of the sly and the shy leads to the abortion of progress. Furthermore, the results of their work, which bar out "chance," "luck," or "happenings," is their most eloquent language to convince their fellow-men that if law-makers may still think that laws are made or unmade by them in Albany or Washington or Harrisburg, there is at least one law which cannot be amended; at least one law which even the cleverest lawyers cannot make to be interpreted in two different ways; a law which rules all men, large or small, poor or rich, to whatever nation they may belong; a law which rules the dead and the unborn as well as the living; a law which requires no supreme court to test its validity; a law that cannot be trifled with, which nobody and nothing can escape—the great, unchangeable law of nature, which rules the universe, mocks at men-made statutes and ordinances, and upsets and destroys everything which comes in conflict with her; the rigidly enforced law which tries to teach us our mis-

takes by suffering, by misery, by industrial or political crisis, by unhappiness, by war, so as to awaken us from our ignorant sleep, to show us our misguided aims and to command us to prepare a sounder, a happier condition for our children and future generations, while building up, during the trend of centuries, a slowly rising foundation for a higher humanity, a more god-like race.

GENERAL LECTURE

BY

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OF

ELBERFELD, GERMANY

THE LATEST ACHIEVEMENTS AND PROBLEMS OF THE CHEMICAL INDUSTRY

EIGHTH INTERNATIONAL

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THE LATEST ACHIEVEMENTS AND PROBLEMS OF THE CHEMICAL INDUSTRY

By Carl Duisberg

Probably in no domain of human knowledge and endeavor have the combined forces of theory and practice, intimately acting and re-acting upon each other, made such immense strides and led to the solution of such difficult problems as in the Chemical Industry, an industry which, indeed, had its beginnings in the distant past, but in its vast development and international character is essentially a child of modern times. Success has so emboldened this industry that it considers itself capable of solving any problem, provided the men in its service are well trained in theory and practice and ready to devote themselves to the best of their ability, with patience and perseverance, to the object in view. This has been shown by the struggle between the contact process of producing sulfuric acid and the old "chamber process"; by the rivalry between the Solvay process and the Le Blanc method in the manufacture of soda; by the production of nitric acid and its salts by direct oxidation of nitrogen of the air under the influence of the heat of the electric discharge; by the manufacture of ammonia from atmospheric nitrogen indirectly via calcium cyanamide, and directly by combination with hydrogen; by the replacement of madder by alizarine, and of natural by synthetic indigo, as well as by innumerable other instances in the color, perfume and pharmaceutical industries.

If, before an audience not wholly consisting of chemists, I venture, within the brief period of an hour, to describe the latest achievements of the chemical industry and to recount the problems that are engaging our attention, I must restrict myself to a great extent both in the choice of the subject matter and its mode of presentation. We can, indeed, merely touch upon the most important happenings in our industry and must, from the very outset, refrain from a thorough discussion of the subject,

either from the purely chemical or the technical side. However, what cannot be described for lack of time, and what we should very much like to add for the sake of those chemists who are present, is illustrated by that rich collection of diagrams, products and materials of all kinds. What can neither be mentioned in my paper nor illustrated by these exhibits, will be demonstrated by means of lantern slides, and, should you possess patience enough, I shall show you at the conclusion of my address one of the newest factories which the German Chemical Industry has built on the Rhine, with its various manufacturing departments and, above all, its provisions for the welfare of its employees.

In the spirit of Faust: "Who brings much will bring something to many," I invite you to make a flight with me in an airship, as it were, over the fields where the Chemical Industry holds sway and, from our point of vantage, to take a bird's-eye view of the latest achievements of this industry. Now and then, we shall make a landing and examine the most attractive features a little more closely.

Production of Power: The question of power, which is of the utmost importance in every industry and especially in the great synthetic processes by means of which nitric acid and ammonia are manufactured, is now dominated by the perfected utilization of hydraulic power and the development of the turbine. Not only does the transmission of electric energy render it possible to utilize water power at great distances, but it also allows of the transmission of power evolved at the coal mines and the peat fields to distant points, thus eliminating the necessity of transporting the fuel itself. Recently, we also learned to apply the principles of the water turbine to the steam turbine. But this advance over the piston steam engine, which Watt so ingeniously constructed about 150 years ago, has already been surpassed by benzine, petroleum or oil motors (Diesel motors), and, above all, by the reliable gas engines which are driven by blast furnace gases, Mond gas, and, more recently, by peat gas.

Production of By-Products: The manufacture of by-products goes hand in hand with this more direct generation of energy from fuel. These products include ammonium sulphate,

of such great importance in agriculture, and the tar distillation products, so indispensable in the color industry. The latest and most rational method of utilizing the peat or turf beds, which are so plentiful in Germany and in many other countries, is practiced in Schweger Moor near Osnabrück according to a process discovered by Frank and Caro. There peat gas is produced and utilized and ammonia obtained as a by-product, the required power being generated in a 3,000 h. p. central electric power station. The moorland, after removal of the peat, is rendered serviceable for agricultural purposes.

At that place, nearly 2,500 to 2,600 cubic meters of gas with 1,000–1,300 calories of heat were obtained from 1,000 Kg. of absolutely water-free peat in the form of air-dried peat with 45 to 60 or 70 per cent. of moisture. This gas represents energy equal to 1,000 h. p. hours, equal to 700 kilowatt hours, after deducting the heat and power used for the operation of the gas works. In addition 35 Kg. ammonium sulphate were produced from the above quantity of peat which contains 1 per cent. of nitrogen.

The greatest problem of power production, the direct conversion of coal into electric energy by means of gas batteries, a problem which we had hoped to solve 25 years ago, is still today nothing more than a dream.

Production of Cold: Besides the problem of power and heat, the question of refrigeration is one of growing importance to the chemical industry. Instead of the ammonia machines with which a temperature of minus 20 C. can be attained, we employ today sulphurous acid machines or, better still, resort to the carbonic acid gasifier which yields a temperature of 40° C. below zero. It is hoped in the near future to produce refrigerating machines, which, by the use of suitable hydrocarbons, will give temperatures of minus 80 C. Plants for the liquefaction of air, producing as low a temperature as minus 190 C., are becoming more and more common and are especially profitable where gas mixtures, rich in oxygen, or where pure nitrogen, which are simultaneously produced, can be utilized. Diagrams showing the process invented by Linde for the rectification of liquid air with the object of isolating nitrogen and oxygen are exhibited

here. The Badische Anilin and Soda Fabrik in Ludwigshafen on the Rhine intends to manufacture hydrogen from water gas in a similar way and to utilize the carbon monoxide, which is simultaneously obtained, as a source of power. In a large plant which is being erected, the firm is going to produce ammonia synthetically by combining, according to Haber's invention, pure nitrogen, obtained by the liquefaction and rectification of air, with hydrogen manufactured as above. Particulars about this process will be given during the Congress by Professor Bernthsen in his lecture on "Synthetic Ammonia."

Size of Apparatus: Influenced by the Solvay process for the manufacture of soda and its pecuniary advantages, the apparatus used in the chemical industry have enormously increased in size. In this respect the United States, no doubt on account of the example set by the iron industry with its blast furnaces with a daily capacity of 500 tons; its giant conveyers (50 ton wagons), its huge hoisting cranes, is ahead of other countries. But careful calculations have proved that there is a limit in this direction. The failure, on account of size, of the Mactear sulfate furnace, with a daily output of 25 tons, is well known, whilst the mechanical sulfate furnace of the Verein Chemischer Fabriken in Mannheim, which produces only 7 tons a day, is a success everywhere. It is not improbable that the high cost of construction and the great loss which accidental stoppage entails will necessitate a reduction in size of the wonderful Wedge furnace, a creation of the United States, which roasts 30 tons of iron pyrites per day.

In the organic chemical industry, the iron vessels for chlorination, sulfonation, nitration, reduction and oxidation, as well as the wooden tanks in which we diazotize and produce colors, have developed from the small vessels and vats of former years into apparatus of mighty size, their limit being generally determined by the capacity of the mechanical industry. But here, too, the mistakes which often occur in manufacturing processes and the extra losses which they involve, teach us that a wise moderation should be exercised.

Wherever possible, continuous operations have replaced those processes which worked intermittently. In this way loss of time and expense, caused by cooling and reheating, are avoided.

This is exemplified by Uebel's new method of the production of nitric acid from Chili saltpetre with retorts lying above each other and without stirrer, and by that of the Badische Anilin and Soda Fabrik, where the chambers are back of each other with stirrer, these methods having replaced the old single retort process.

MATERIAL: As regards the material for chemical apparatus several new wares must be referred to:

Quartz Vessels: Apart from the fact that the saltpetre industry of Norway taught us how to absorb dilute nitrous gases in towers 20 meters high, made of granite, a substance which was rarely used for chemical purposes, we have today at our disposal tubes, dishes and vessels of fused quartz, which are stable against acids and heat and which are manufactured in the same sizes and dimensions as the well-known earthen ware vessels.

Refined Steel: The greatest progress, however, has been made in the manufacture of iron alloys or refined steel.

Thanks to the kindness of Friedr. Krupp of Essen, I am in the fortunate position to describe a large number of hitherto unknown substances of great importance, of which I exhibit magnificent specimens, photographs, and lantern slides. Just here, however, I must ask you to make one of the landings from the upper air and permit me to deal with the subject at greater length. You will be astonished at the immense progress which has been made to the general benefit of our industry.

Of the greatest interest are the alloys of iron with other heavy metals and metalloids, i. e., alloyed steel.

Instead of carbon, other elements are employed, which likewise enhance the hardness of steel, but prevent the formation of a crystalline micro-structure liable to cracks and flaws. The most important of these elements is nickel.

Nickel Steel: The readiness with which nickel forms an alloy with iron has long been common knowledge. Even in Bessemer's days, attempts were made in Great Britian to turn out cannons made of steel containing 2 per cent. nickel. The experiments were not successful because the nickel obtained at that time contained impurities, such as copper, arsenic and sulphur, so that the steel could not be forged. Thirty years later pure nickel, as we know it today, made successful results possible. The same

was the case with chromium, silicon and manganese, and not until these elements were produced pure, could successful alloys be manufactured with them, either alone or together with nickel. The chief aim in the manufacture of these alloys is the formation of an amorphous, pliable structure of the steel. This result is attained not only by removing more or less of carbon, but above all by a certain thermic treatment, namely, by suddenly cooling steel heated to a high temperature, heating again and keeping it at a certain lower temperature. You will see two samples of steel; in the one case, the coarse crystallization of the pure carbon steel before it is forged, and in the other, the same steel refined by the thermic treatment. The difference in the micro-structure of the forged carbon steel and that of the forged and thermically treated nickel steel must also be noted. Whilst carbon steel after forging still shows a crystalline structure with visible cleavage planes of the crystals, the section of nickel steel displays an amorphous structure closely resembling that of welded iron. For comparison sake, a sample of a welded iron fracture is exhibited. It must not be overlooked, however, that nickel and chrome nickel steels are twice or three times as hard as welded iron. There are also exhibited test pieces of construction parts to be used in the automobile industry made of alloyed steel. Notwithstanding the high tensile strength of about 90 kilos per square millimeter (i. e. about 55 tons per square inch), no fracture is noticeable although they are greatly bent.

Aside from these improvements, which are of such great moment for structural steel, the iron alloys have found many new applications.

I merely mention the different nickel alloys for ship-building, electric appliances, and for valves. These valuable alloys containing 23 per cent. and more nickel, are non-magnetic, and not affected by atmospheric influences; those containing 30 per cent. nickel possess great resistance to electricity, whilst the co-efficient of expansion of steel with 45 per cent. nickel is only one-twentieth of that of ordinary steel and not greater than that of glass.

Chromium, Tungsten, and Molybdenum Steel: It is a very interesting and novel fact that by the thermic treatment alone the micro-structure of the cheaper kinds of unalloyed iron plates

and iron shapes is so changed that it becomes three times as resistant to the destructive effect of acids. If alloys of iron with chromium, tungsten, molybdenum and aluminium in certain proportions are thermically treated, this resistance is increased five-fold, as is shown by samples of ordinary carbon steel and chrome nickel steel which underwent a treatment with dilute sulfuric acid for 56 days.

An alloy of ordinary iron with 5 per cent. nickel is an excellent material for withstanding hot caustic soda. Most astonishing properties are displayed by steel alloys containing more than 10 per cent. of chromium and a small addition (2 to 5 per cent.) of molybdenum. Such alloys are manufactured in the form of malleable cast and forged iron pieces by Krupp according to the patents of Borchers and Monnartz in Aix-la-Chapelle and in the form of rolled tubes by the Mannesmann Röhrenwerken in Remscheid. These alloys are insoluble not only in dilute hydrochloric acid and sulphuric acid, but also in dilute nitric acid, even with the addition of alkali-chlorides, and if they contain about 60 per cent. chrome, 35 per cent. iron, and 2 to 3 per cent. molybdenum they withstand even boiling aqua regia. You will see samples of this extraordinary steel, after treatment with acids, compared with ordinary steel and cast iron.

Tool Steel: It must be especially mentioned that the alloys of iron with chromium, tungsten and molybdenum tempered by a special process invented by two Americans, Taylor and White, find most important uses as quick turning steel for all kinds of tools.

Vanadium Steel: The most recent improvements in the manufacture of steel for tools which must of necessity keep pace in hardness with structural steel have been made by the employment of vanadium. Unfortunately, this metal, the use of which is steadily increasing, is still very dear, and the problem which chemists have to solve is to produce it more cheaply. If the price could be reduced perceptibly, metallurgists prophesy a great future for this metal, which exercises a very favorable influence on the micro-structure of steel.

Of great importance are those alloys of iron with chromium, tungsten and vanadium which possess a high degree of hardness

even at 400–500 C. They are needed by engineers for the construction of steam turbines, for the embossing and spraying of metal objects when heated to redness, a process which has lately found extensive application. Chemists use these kinds of steel whenever chemical reactions are carried out at high temperatures and pressure, e.g., for the synthesis of ammonia according to Haber's process.

The very latest alloy has now been patented and is being manufactured by Krupp for the construction of safety vaults and safes. This steel can neither be drilled nor exploded, nor can it be cut by the oxy-hydrogen flame.

Two samples of steel are exhibited, one of ordinary steel in which great holes have been cut in $5\frac{1}{2}$ minutes by using an oxy-hydrogen flame and in 6 minutes by an oxy-acetylene burner, and a specimen of this new alloy which has remained intact after being treated with the same oxy-hydrogen and oxy-acetylene flames for $1\frac{1}{2}$ hours. Let us hope that on this hard and infusible material the scientific safe-burglar will exercise his noble art in vain.

Manganese Steel: Of the alloys made with manganese, the manganese steel or hard steel, first produced by Robert Hadfield, because of its great wear, is chiefly used for cast iron parts of disintegrators and rails of electric tramways. On account of its hardness, this steel is not malleable, but it can be bent in the cold state and is thus very safe against breaking. It is therefore of much interest to the chemical industry where, in almost all branches, grinding operations are carried out.

Silicon Steel: Finally, I wish to refer to alloys of iron and silicon which contain $1\frac{1}{2}$–$2\frac{1}{2}$ per cent. silicon and a high percentage of carbon. This steel is excellently adapted for tools and springs which must stand high strain. Since steel alloys containing much silicon, although brittle and porous, have proved very stable against acids, they are now being used more and more where such a property is of importance.

Alloys with about 4 per cent. silicon, but very poor in carbon, are of greater value than the above. Robert Hadfield first pointed out the importance of this alloy, whilst Krupp working, in connection with Capito and Klein, a firm of fine-plate rollers

in the Rhineland, considerably improved it and introduced it for electric purposes. It is employed in large quantities in the form of sheets of 0.35 mm. (1/70 inch) thickness for the construction of dynamos, alternate-current motors and transformers. In Germany alone, the consumption of this alloy already amounts to 8,000 tons a year. This material has a resistance to electricity 4 or 5 times greater than that of ordinary iron and loses only half as many watts, so that the injurious Foucault currents are reduced to a minimum. The manufacture of transformers has therefore become much cheaper, for the proportion between iron and copper is much more economical. The production of this silicon iron alloy with its very low percentage of carbon, and that of the chrome nickel steels almost free from carbon, became possible only after silicon and chrome, entirely free from carbon, could be manufactured by electric smelting processes.

Electro-Steel: Since the electric smelting furnace has come into use in the steel industry, the problem of removing sulphur, which engaged the attention of chemists for so many years, has been solved. It has been found that the electric furnace process produces a slag free from metal, and such a slag is the prime requisite for the complete desulphuring of the steel bath.

Electrolytic Iron: Superior to the silicon steel, poor in carbon, in its electric properties is the "Ideal" metal for electromagnets —the pure electrolytic iron—first produced by Franz Fischer, of Charlottenburg, and now manufactured by the firm Langbein-Pfanhauser & Co., Leipzig. Formerly it was impossible to produce it free from hydrogen, consequently it was hard and brittle and was not malleable. Only by electrolyzing at 100–120 C. and employing an iron salt solution mixed with hygroscopic salts, such as calcium chloride, the iron became free from hydrogen. Its hardness then sinks far below that of silver and gold and is not much greater than that of aluminium. It possesses the valuable property of becoming magnetic more quickly than ordinary iron, containing carbon or silicon, and also of again losing its magnetism more readily, thus considerably increasing the efficiency of electro-motors, for which it is used. Amongst the exhibits, you will find several objects made of this electrolytic iron; for example, a cathode made from an electrolytic iron

plate during 5 days of uninterrupted operation; also plates made by rolling; further a motor which, if constructed of silicon iron, would furnish 0.5 h.p., but being composed of electrolytic iron, though in use for several months without appreciable signs of wear, it now furnishes 1.3 h.p., in other words, it is $2\frac{1}{2}$ times as efficient.*

With all these new materials at our disposal, among which I must also mention copper, with 10 per cent. silicon, and copper nickel, we shall surely be able to improve all sorts of chemical apparatus that suffer so much from wear and tear.

After this short invasion of the domain of metallurgy, we shall now turn our attention to the chemical industry proper, first dealing with the manufacture of inorganic substances, the heavy chemicals.

Sulphuric Acid: The triumphal progress of the contact process for the manufacture of sulphuric acid in the United States scarcely has its parallel in Germany, where it originated. Platinum, in spite of the fact that its price has increased threefold, is still our principal contact agent. As it is possible to carry out other contact processes with various contact materials, we shall certainly find other agents than platinum available for sulphuric acid anhydride. It ought therefore to be a fruitful field for research to find cheap substitutes for platinum. The Americans in the 20 years that have elapsed since Knietsch first successfully carried out the contact process, have increased their output threefold for the same weight of platinum. Nevertheless, the old lead-chamber process still competes with the new method, and the steady improvement of this process and the purity of the resulting acid must be acknowledged. In fact, the lead-chamber process promises to make further progress in the future in view of the success of Falding's high chambers and Opls towers in which large quantities of acid flow down.

The Gaillard tower is supreme for concentration and recovery of the acid and for the regeneration of the various waste acids.

Ammonium Sulphate: A new way of manufacturing sulphuric acid, together with ammonia, from the gases which are produced by the dry distillation of coal, is looming above the

* See Zeitschrift für Electrochemie, No. 16, 1909.

horizon. Burkheiser is seeking, with the aid of especially prepared wet iron compounds, to bind the sulphur, simultaneously absorbing cyan, and to convert the ammonium sulphite thus produced into ammonium sulphate by oxidation with atmospheric air.

In competition with Burkheiser, Walter Feld is endeavoring to recover sulphur directly as ammonium sulphate by a series of interesting reactions, in which thiosulphates play an important part. Such plants are in operation in Königsberg and here in New York.

Nitrogen Compounds: So much has been written concerning the progress made in the last 5 years in the utilization of atmospheric nitrogen, that I need not enter into a description of Birkeland-Eyde's, Schönherr's or Pauling's process for the direct oxidation of nitrogen by means of the electrical discharge, nor of Frank-Caro's method of forming cyanamide from carbides [The world production of cyanamide is, according to Dr. N. Caro, 120,000 tons per year, of which 31,000 tons are manufactured in Germany (16,000 in Trostberg and 15,000 in Knapsack near Cologne), 19,000 tons are made in Niagara Falls by the American Cyanamide Co., and during the next three years the total production is to be increased to 200,000 tons], nor is it necessary to describe the Serpek process for the production of ammonia from aluminium nitrides combined with the utilization of alumina which is simultaneously obtained. I will mention, however, that the problem of concentrating the dilute nitric acid, as obtained in the large absorption apparatus from nitrous gases, has been solved by Pauling's method, in which sulphuric acid is used in a battery of towers. It is also possible now to convert economically cyanamide into ammonia and this again into nitric acid.

Soda and Chlorine: The 50 year old Solvay process, which has conquered the whole world, still remains master of the situation. This is all the more remarkable since it is still imperfect as far as the yield is concerned, for a quarter of the salt used in the process is lost as such, and the whole amount of chlorine in the form of calcium chloride.

Although the materials employed in the LeBlanc process are completely utilized, this fact will not give it any chance of surviving, and it would seem to be now chiefly of historical interest.

Not less remarkable is the 25 years' career of the alkali-chloride electrolysis. The limited market for chlorine compounds and the great space taken up by the electrolyzing baths were great obstacles to the progress of this apparently so simple method. For the same reasons the most approved processes, such as the Griesheim cement cell, the quicksilver cathodes of Castner and his successors, the Aussig Bell and the wire-gauze diaphragm of Hargreaves, with its many varieties, of which the Townsend cell is the latest and best, did not develop as expected. The limited demand also quickly restricted the operation of the brilliant method of manufacturing chlorates by electrolysis.

Tin: Tin is not only produced from natural ores, but also in more than 20 detinning establishments from tin-plate and tin-can waste; 200,000 tons of tin-plate waste are subjected to this treatment and about 24 million Marks ($6,000,000) worth of tin and iron are recovered. The electrolytic detinning process, on account of high wages, the great cost of current, and the considerable manufacturing loss, has been replaced,—where there is a market for chloride of tin,—by the patented process of Thomas Goldschmidt, of Essen. This process takes advantage of the properties of chlorine gas, in the dry state, to greedily take up tin without reacting on iron if certain temperatures are observed. Instead of the inferior quality of electrolytic tin mud, which must be converted into marketable tin by costly smelting operations, the new process yields an anhydrous tin chloride, which is used in large quantities for weighting silk. The detinning with chlorine is not carried out with cuttings, as in the electrolytic process, but with waste pressed in hard packages, so that 20 times as much material can be treated in the apparatus at the same time. In the United States this process is operated by the Goldschmidt Detinning Company of New York.

Reducing and Oxidizing Agents: One of the most brilliant successes in applied chemistry has been achieved by the persevering experiments of some chemists with a long neglected substance, the constitution of which had never been properly understood. The old hydrosulphite of Schützenberger, rendered stable and easily transportable in powder form as an anhydrous sodium salt or as Rongalite in combination with formaldehyde,

has now become a most important article of commerce. It is chiefly used in vat dyeing and for reducing purposes in general, such as stripping dyed fabrics and as Decrolin for bleaching sugar.

Peroxid of Hydrogen, *Persulphate and Perborates:* Peroxid of hydrogen and its derivatives at present find less favor in commerce, although their future appears to be very brilliant. Recently the Farbenfabriken vorm. Friedr. Bayer and Co. succeeded in rendering this important oxidizing agent, which easily decomposes and which can be marketed with difficulty only in watery solution, solid and stable by the addition of urea.

This powder is in the market under the name of Ortizon, but on account of its relatively high cost it is intended not so much for technical as for hygienic and pharmaceutical purposes.

The interesting manufacture of sodium peroxid from sodium and the many scientific investigations of the persalts, have not been followed by great commercial success. The persulphate and perborate, however, the latter under the name of "Persil," are being manufactured on a large scale. The reason of this failure seems to be the high cost of production.

Rare Metals: The most interesting alloys discovered by Muthmann and Auer have found little application in the arts, and the use of cerium- and thorium-preparations is still confined to the incandescent gaslight industry. Only the "Auermetal," consisting of 35 per cent. iron and 65 per cent. cerium, is employed and this only to a limited extent for the manufacture of pocket cigar lighters.

In the metal filament lamp industry, tungsten, which shows the highest melting point of all metals, namely 3100°, has replaced tantalum, which melts at about 2300°. This became possible only after successful experiments to render the metal ductile by hammering.

The elements cadmium, selenium and tellurium are obtained in great quantities as by-products; the first is produced in the zinc industry, the other two from the Tellur gold ores which are found in Cripple Creek, Colorado. Although they are sold at relatively low prices they find but little use in the industries.

Artificial Precious Stones: Finally, I will, in but a few words, touch upon a new industry, viz., the synthetic manu-

facture of precious stones from alumina with additions of chrome oxide, iron oxide or titanic acid. Artificial rubies and white, yellow and blue sapphires, which cannot be distinguished from natural stones, are being manufactured in great quantities in Paris and recently also by the Electrochemische Werke, Bitterfeld. They are used extensively for jewelry and especially as bearings in watches and measuring instruments.

All this will give you a striking picture of the development of inorganic chemistry which is taking a more and more important position beside organic chemistry.

Applied Organic Chemistry: In the organic chemical industry the reactions are considerably more complicated and the apparatus mostly smaller than in the inorganic industry. Here the chemist, like a juggler with his balls, gives every atom a definite position in the many thousand combinations which carbon forms with hydrogen, oxygen, nitrogen and sulphur, and there exist the most varied reactions and processes which may lead to the same result. This chemistry of the carbon compounds has been most wonderfully perfected in the coal-tar color industry, and in every factory of this branch there are hundreds of scientifically trained chemists always experimenting and daily finding new combinations possessing properties of technical value. Before these products become finished articles to be sold as colors, perfumes or pharmaceutical preparations, they must further go through a series of numerous intermediary operations, which finally lead to the marketable chemicals.

Coal-Tar: The starting material of the important coal-tar color industry is the black tar which is obtained by the dry distillation of coal and is known to contain about 150 different chemical products, of which, aside from carbolic acid, the aromatic hydrocarbons, benzole and its homologues, toluol and xylol, naphtalene and anthracene, play the greatest part.

More recently carbazol has been isolated from tar on a large scale and has become a most important raw material for the manufacture of the color "Hydronblue" by Leopold Cassella and Co., Frankfort o/M. Hydronblue is a sulphur dyestuff distinguished by its fastness against washing and chlorine. Acenaphthen, which also occurs in coal-tar as such, is the starting

material of a red vat dye "Cibanonred," discovered by the Society of Chemical Industry in Basle. It is to be regretted that hitherto no technical use has been found for phenanthrene, which is also one of the constituents of tar.

Besides carbolic acid, its homologues, the various cresols, etc. are being isolated by Dr. F. Raschig in Ludwigshafen on the Rhine. These substances are largely employed in the manufacture of explosives and coloring matters.

As long as coal gas is produced for illuminating and heating purposes and as long as coke must be used for the reduction of iron ores, tar will always remain the cheapest raw material for the manufacture of these hydrocarbons. But since it may become necessary in the future—as is already possible today—to use coal in a more rational way, at the same time producing hydrocarbons, the coal-tar color industry need not fear a scarcity of this important raw material, the less so as certain kinds of petroleum, e. g., Borneo petroleum, contain large quantities of aromatic hydrocarbons from which the Rheinische Benzinwerke, in Reisholz near Düsseldorf, has already isolated toluene in the form of nitro-toluene in a commercial way. If, however, a still greater demand for these hydrocarbons should occur, other methods of obtaining them must be found. We shall then surely succeed in producing them synthetically either directly from the elements carbon and hydrogen or indirectly from carbide of calcium by passing acetylene through glowing tubes—a reaction which was already carried out successfully in the early sixties of the last century by Berthelot and recently by Richard Meyer. At the present time about one-quarter of Germany's annual output of coal is converted into coke, viz. 20 per cent. for foundry purposes and 4 per cent. in gas works, whilst in England the quantities are 12 per cent. and 6 per cent. respectively.

Distillation of Tar: The point of greatest importance in the distillation of tar is still the separation and isolation, in the cheapest possible way, of the different hydrocarbons in their purest form. The stills have been continually enlarged, those employed to-day having a capacity of 60,000–80,000 litres (13,000–17,500 gallons). On the other hand, a continuous process, such as is possible in the bituminous coal-tar industry, has not yet

been found. A large number of patents have been taken out for apparatus intended to solve this problem, but none of them have proved satisfactory in practice.

Organic Intermediate Products: The conversion of the aromatic hydrocarbons into intermediate products necessary for the color industry is almost always carried out by treatment with concentrated sulphuric and nitric acid and subsequent reduction of the thus obtained nitro-compound by means of metals, metalous oxids and metal sulphides. In the productionl of amines, iron is the principal agent of reduction, while zinc and tin are mostly used in the production of azo-compounds. The electrolytic reduction has not proved useful for these processes.

The methods of producing nitro- and amido-compounds have been very little changed as far as chemical operations are concerned, but with the increase of their production their poisonous properties became more and more apparent and forced the manufacturer to modify the processes so that they could be carried out in tightly closed vessels in order to protect the life and health of the workmen.

In Germany legislation has been recently enacted, based on the experience of the individual factories, which lays down rules and regulations for strict observance.

Several trinitro-compounds have been shown to be good explosives, and, like trinitrotoluene, are now largely employed as substitutes of picric acid in the manufacture of explosives.

The introduction of oxy-groups into the molecule is mostly brought about by melting sulpho acids with alkalies, and, according to more recent methods, with alkaline earthmetals, such as calcium- and barium-hydrate. Since chlorine, produced electrolytically, is obtainable in unlimited quantities and chemically pure, chlorine substitution derivatives of the hydrocarbons have been employed for all kinds of synthetical purposes. Many of these chlorine derivatives can not only be converted into oxy-derivatives by melting with alkalies, but, like paranitro-chlorbenzole, they also directly exchange their chlorine for an amido group when treated with ammonia or its derivatives. Colors also often change their shade when a halogen atom is introduced

into their molecule and acquire more valuable properties. Chlorine has therefore proved exceedingly useful in the preparation of intermediate products and will undoubtedly become of still greater service in the future.

In the naphtaline series, the method discovered by Bucherer and Lepetit for the conversion of the hydroxyl group into the amido group and vice versa, employing sulphurous acid esters, has proved of great practical value. Phosgene, too, is, to-day, being more and more employed. Several decades ago it became an important substance for the production of the urea of para-amidobenzolazo-salicylic acid, introduced into the market, under the name of "Cottonyellow," as a beautiful yellow cotton color of great fastness to light. It's principal use, however, was for the manufacture of the bright but fugitive triphenylmethane colors. It is now especially used to combine 2 molecules of aromatic compounds with free amido groups, thus producing urea derivatives, and if the starting material is an azo color, the resulting urea derivative is, as a rule, much faster to light than the original color. Imidazol, thiazol and azimido compounds of the most varied kinds are also manufactured and converted into azo colors.

In the series of the aldehydes and carboxylic acids there are no epoch-making discoveries to be recorded. Chemists still start from hydrocarbons chlorinated in the sidechain or directly oxidize the homologues of benzole. Kolbe's synthesis of salicylic acid, of which large quantities are used in the color industry, is also applied at an ever-increasing rate for the production of the oxycarboxylic acids. But the direct introduction of the carboxylic group into the benzole molecule, unsubstituted by hydroxyl, is a greatly desired achievement which, however, has not yet been attained. It is also a matter of greatest importance that in substitution reactions of the aromatic nucleus we should be able to vary at will the ratio of the isomers to be formed.

Besides the biochemical production of ethylic alcohol from wood waste and from the waste liquors of the sulphite cellulose industry, I wish to mention the synthesis of organic compounds by the addition of water to acetylene. In this manner we produce in a simple way acetaldehyde, which can be easily converted into

acetic acid, a very important starting material for the manufacture of numerous products.

The steady search for new raw materials and new intermediate products to be utilized in the manufacture of colors has often been crowned with success. We need only to recall the many intermediate products which have been made available for the production of the vat dyes and sulphur colors and which have led to the discovery of new substances with most valuable properties. Very often new lines of research are not always based upon preconceived theoretical ideas, but are opened up by mere accident. A keen power of observation, however, is the most necessary equipment of the chemist who aims at success.

Coal-Tar Colors: In no branch of technical chemistry has such intense work been performed as in that of the coal-tar color industry. The outsider long ago may have thought that so much had been accomplished in this field that nothing more was left to be done. The countless dyestuffs, giving all the colors of the rainbow, might well have given rise to the belief that there was already a surplus. But here the course of events was just as it generally is in life. With growing possessions, man's needs and demands also multiply. While people were formerly content to produce with coal-tar colors every possible shade in undreamt-of brightness in the simplest way, they gradually began to make more and more exacting demands as regards fastness. Not only had materials to be dyed a pleasing shade, but they also had to be fast to washing and light. Thus new, alluring problems were submitted to the color-chemist, and his indefatigable efforts have already carried him a long way towards the desired end. Strange to say, amongst the public, you will frequently meet the view that artificial colors do not give fast dyeings. This is a decided error which cannot be too emphatically contradicted. Today we can produce almost any shade with any desired degree of fastness on any kind of material, whether it be wool, cotton, silk or paper. If the dyer does not always produce such shades it is the fault of the trade which does not express its demands forcibly enough. Of course, the dyeing with fast colors entails a somewhat greater expense which must naturally be borne by the consumer.

Just at this point, before discussing the progress made in the manufacture of fast colors and in order to prevent misunderstanding, I should like to emphasize the fact that the old colors, though not as fast as those more recently discovered and though, perhaps, quite fugitive in some respects, still have a right to exist. It would be quite foolish to dye certain kinds of paper intended to be in use for only a very short time, with colors absolutely fast to light, or to dye cloth never to be washed, with expensive colors fast to washing, or, again, to treat lining, which is but slightly exposed to sunlight, in the same way as materials which must be exceedingly fast to light. Everything according to reason. For many purposes, however, the need for shades fast to light or to both light and washing is so great that it must be given every consideration. How mortifying it must be to notice shortly after you have decorated the walls of your home with most beautiful and expensive materials, that the lovely colors daily grow more unsightly, and to see a solitary patch showing up in all its pristine glory amidst a faded background when a picture or other piece of furniture is moved to another place. As it is possible to guard ourselves against such occurrences, we should certainly do so. Today we are able to produce the most beautiful colored wall-coverings, whether of paper or of woven or printed fabrics, to meet every requirement in regard to fastness. This is proved by the large collection of all kinds of woolen and cotton fabrics (after washing and exposure to light) and especially of wall-papers, of carpets, rubber material and balloon coverings, which the different firms of the German color and dyeing industry have placed at my disposal for exhibition.

If you now inquire how chemists have been able to make such great progress, my only answer is by logical and untiring efforts along well-known ways, undaunted by failures, and by diligently following any track, however faint, that gave promise of advance.

In every branch of the color industry these methods have led to faster and ever faster dyestuffs, from the multicolored benzidine colors, described as fugitive to light and not stable to washing, to the anthraquinone colors and the indigoid vat dyes. In all these classes we have gradually learned to recognize certain regularities and to accomplish certain results by systemati-

cally grouping the components and fixing the position of the substituting groups, and thus we have succeeded in increasing the fastness to light of the individual chemical according to a preconceived plan.

Indigoid Colors: The synthetic production of colors allied to indigo was stimulated by the successful synthesis of indigo which almost entirely displaced natural indigo and called the attention of both chemist and consumer in an increased measure to the advantages of vat-dyeing. The King of Dyestuffs, Indigo, now finds itself in the company of a whole series of other colors, the brome indigos, the thio indigos and alizarine indigos, the shades ranging from blue to red, violet, grey and black. Even the "purple" of the ancients has been reproduced by Paul Friedlaender, who by isolating the dyeing principle found in certain glands of the purple snail living in the Mediterranean, has demonstrated the fact that this natural color is identical with a dibromindigo which had been long before produced synthetically. These indigoid colors possess the same, if not better properties as indigo itself.

Alizarine Colors: The fastness of the alizarine colors, e.g. alizarine red, used for Turkey red, was well known in ancient times. But, whereas formerly only mordant colors were considered to be fast, and consequently only these were looked for in the anthraquinone group, which led to the discovery of alizarine-orange, -brown, -blue and the alizarinecyanines, Robert E. Schmidt, in 1894 to 1897, succeeded in finding acid-dyeing anthraquinone colors which dye every shade, rivalling the old and well-known triphenylmethanes in brightness and simplicity of application and the alizarine mordant colors in their extraordinary fastness to light. I merely mention alizarine cyanine-green, alizarine-sky-blue, anthraquinone-blue, alizarine-sapphirole, -astrol, -irisol and -rubinol. Their fastness to light is so excellent that in the famous "Manufacture Nationale du gobelins" in Paris, they have replaced the older dyestuffs for the dyeing of wool used in the manufacture of gobelins. This means a great deal if it be borne in mind that a square meter of these gobelins for the production of which an operator needs more than a year, costs, on the average, about 6,000 francs.

Indanthrene and Algole Colors: An entirely new era began for the alizarine series when Réné Bohn in 1901, found that his new color, indanthrene, could be used as a vat-dye for cotton. This color can be dyed in its reduced state like indigo, but is far superior to the latter in beauty and brightness of shade, as well as in fastness to washing and light. Indeed, the fastness to light is so great that in this respect it must be termed indestructible.

On account of this phenomenal fastness, indanthrene blue caused chemists to look for other vat colors in the anthraquinone series. Their efforts did not remain unrewarded, and we already possess colors of this class giving every possible shade. The Badische Anilin and Soda Fabrik sell them under the name of "Indanthrene Colors," the Farbenfabriken vorm Friedr. Bayer and Co. under the name "Algole Colors." Chemically most of these vat colors belong to the indanthrene type ; some of them are still more complicated nuclear products of condensation of several anthraquinone molecules; others, again, rea di- and tri- anthraquinonylamines. It must also be noted that to the greatest surprise of all experts in this branch, it was discovered in the laboratory of the Farbenfabriken vorm. Friedr. Bayer and Co., that even some of the simplest acyl derivatives (-benzoyl) of the aminoanthraquinones are excellent vat colors.

Lake Colors: We must not leave out of sight the importance of some colors of the aniline group and especially the anthraquinone group for the production of lakes for paints and pigment colors for wallpaper. The alumina lake of alizarine, the so-called madder lake, with its fine shade and great fastness to light, is best known. Other alizarine colors also yield valuable alumina lakes; thus, alizarine sapphirole gives a blue lake of excellent fastness to light. But it is not always necessary to precipitate lakes. Some of the difficultly soluble vat colors may be directly employed in a finely-divided form. Thus indanthrene and algole blue already play important roles as substitutes for ultra-marine for bluing higher class paper, textiles and even sugar.

The development of the anthracene colors, aside from the

tinctorial progress, brought about remarkable results in pure chemical research, for example the peculiar action of boric acid and the catalytic action of quicksilver in the sulphonation processes of anthraquinone.

But in this branch of our science as well there is still much room for development. Many problems remain unsolved and new ones are continually arising. To satisfy the demand of the dyer many dyestuffs must still be synthetized.

The ceaseless efforts of the color chemist will undoubtedly bring us farther and farther along this road, and complaints about the insufficient fastness of dyed materials will be silenced at last. If this goal is to be reached, it is absolutely necessary for the consumer to support the manufacturer, and I take this opportunity to state that in the United States of America these fast colors are today more generally used and found recognition and widespread application here earlier than in any other country.

Pharmaceutical Chemistry: I will now deal with the progress and problems of the pharmaceutical industry in the synthetic production of medicinal drugs. This industry is the youngest daughter of the coal-tar industry and it is not long since she celebrated her 25th anniversary. Those, who, like myself, had the good fortune to stand at her cradle when Ludwig Knorr discovered antipyrin, and to guide her first tottering steps at the time phenacetin and sulfonal were brought out, must look back with a joyful heart to this period of splendid growth. Much brilliant work has been accomplished but a vast amount still remains to be done. Here we see chemistry and medicine intimately bound together, the one dependent upon the other and powerless without its aid. What an organization, what boundless intelligence is necessary and what immense energy has to be expended in order to discover a new synthetic remedy and to smooth its path through the obstacles of commerce! First, we need a fully-equipped chemical laboratory, then a pharmacological institute with a staff of men trained in medicine and chemistry, an abundance of animals to experiment upon, and finally—the latest development in this field—a chemo-therapeutic and bacteriological department equipped according to the ideas of Professor Ehrlich; these in close connection with one another. Whatever has been

evolved, and after much painstaking effort selected as useful, finds its way into the manufacturing department, there to be elaborated in the most minute details and brought to the highest possible pitch of perfection. Now begins the arduous work of the scientific department! Here the right sponsors must be found, here all prejudices must be brushed aside and an extensive propaganda initiated. Next, a host of clinicians and practitioners must be called into requisition so that what has been evolved in the silent workshop will be conducted on a staunch ship into the wide sea of publicity. And, finally it is the calculating salesman's turn; he must bring in enough to cover all the expenses of the innumerable experiments that have been made, if the new drug, which has swallowed so much money, is to survive and prosper. Truly, all this is a task which only too often is misunderstood and insufficiently appreciated. If, however, a great hit is made—an event almost as rare as the Greek calends—then the envious, the patent- and trademark-violator, and even the smuggler, cling to our heels and seek to rob us of our profits which, taking everything into consideration, are really not large. But despite all this, and though unfortunately opposed by druggists and physicians even today, the pharmaceutical industry serenely pursues its task. For besides certain economic aims, we also have ideals to strive for. We combat systematically the symptoms of disease and are the faithful auxiliaries both of the doctor and the harassed nurse. The agonizing pains of the patient we allay with narcotics and anesthetics. When sleep flees the couch of suffering, we compel it to return; fever, we banish. We destroy the minute organisms which cause and spread diseases. Thus we add to the store of what is valuable, and perfect what already exists. We also isolate the active principles of various drugs and thus assure exact dosage and freedom from undesirable or even dangerous by-effects.

In the chemical works of Germany pure chemical science receives its due. In every branch of inorganic, organic and physiological-biological chemistry we are working with an army of scientifically trained men. In synthetic chemistry, brilliant achievements have fallen to our share. Quite recently, Stolz suc-

ceeded in building up adrenalin,* Decker in making hydrastinin and Emil Fischer and Wilhelm Traube in producing purin bases. All of these are magnificent accomplishments, and many of them have been effected in the laboratories of the industry.

That even yet, as at the beginning—the antifebrin period—we must trust to chance is shown by the discovery of atophan, the latest valuable antiarthritic, which is due to a fortunate accidental observation. In the subject of the old ergot problem, research work is gradually bringing more light and makes the possibility of synthetically producing a substitute a thing of the near future. The Publications on this subject show that hemostatic alkaloids possess a comparatively simple constitution. That sedatives have their place in an age when nervous disorders are so common is not to be wondered at. I need merely remind you of the new adalin which has proved exceedingly useful. Recently, Emil Fischer, the master of chemical research, to whom the pharmaceutical industry is indebted for the synthetic purin bases, viz. caffein, theobromine, and theocin, as well as the valued remedies, veronal and sajodin, has succeeded, after long and fruitless labors, in elucidating the constitution of tannin and producing it synthetically. He has thus proved that it might be possible to manufacture tanning agents of all kinds artificially and has opened up a new and promising field for research.

Chemotherapy: But a short while ago, Ehrlich drew attention to another promising branch of pharmaceutical-medical chemistry, viz. the treatment of infectious diseases by chemical means. After many years' arduous labor and after many thousand experiments on different animals this master of medicine and chemistry succeeded in demonstrating that it is possible to produce chemical substances which will kill the parasites in the human body without injuring their host and that this action is a function of the chemical constitution. The new science, with its magical bullets directed only against the injurious

* 1 kg. adrenalin, which is now prepared synthetically, and has been introduced under the name of "supreranin" by the Farbwerke of Hoechst, requires for its production the adrenal glands of 40,000 oxen. This product, as well as numerous other glandular preparations, is nowadays manufactured by the large American slaughter houses themselves.

organisms in the body, but not affecting its cells, pursued its course from aminophenyl-arsinic acid (atoxyl) to diamino-oxyarsenobenzole (salvarsan). Thus a new synthetic preparation, an arsenic compound, is added to the old and highly effective remedies, mercury, quinine and salicylic acid. It is certain that we are here only at the beginning of a new development. We know already that we are able to combat not only spirochetes but also bacterial diseases, like tuberculosis. Even carcinoma and sarcoma, those growths so destructive to humanity whose cause is, however, not yet understood, can probably be influenced in a like manner by means of selenium compounds, as first pointed out by Emil Fischer. But were we to learn to cure diseases due to trypanosomes and plasmodia, what a great work we should have accomplished in the interest of humanity and social economy, for it is in the most fruitful lands indeed that these diseases, malaria and sleeping sickness, are to be found, and man and beast are ruthlessly destroyed by them. Neither salvarsan nor atoxyl are of service here, and therefore other hitherto unknown remedies must be found.

While the treatment of syphilis, with its terrible consequences, is still imperfect in spite of mercury and salvarsan, let us hope that the systematic experiments carried out in the laboratory with the innumerable products which chemistry is able to produce from mercury and from arsenic will finally lead to complete success.

Synthetic Perfumes: In the perfume industry the developments made since the scent of the violet was imitated with jonon, and since the successful synthesis of camphor from turpentine, are not of such nature that we need to deal with them at great length. The importance of this industry appears from its yearly turnover of 45–50 million Marks (10 to 12 million dollars). Here the efforts of the chemists are directed towards determining the constitution of the complex and simple natural perfumes, isolating the various products of decomposition obtained during the investigation, and finally reproducing the natural perfumes synthetically. Such results have already been achieved in the case of the odor of the rose, lily-of-the-valley and violet. Very

often certain substances are needed in the compounding of perfumes which like indole possess anything but a pleasant smell.

ARTIFICIAL SILK: Even if doubt be expressed as to whether artificial silk (the yearly consumption of which amounts to about 7 million kilograms) still belongs to the chemical industry because it stands in such close relation to the textile industry, with its weaving and spinning machines, yet the raw materials needed for its production, such as nitro-cellulose, copper ammonia cellulose and cellulose-xantogenate are of such importance that the chemist and engineer equally divide the responsibility in this branch of manufacture. Viscose silk from xantogenate of cellulose, the production of which has been recently very much improved, seems to replace nitro-cellulose silk and the copper ammonia silk. This viscose silk surpasses all other artificial silks in lustre and is the cheapest to manufacture, so that the apparently simplest process of all, the copper ammonia cellulose silk, cannot compete with it any more. Among the exhibits are fine specimens of this silk from the Vereinigten Glanzstofffabriken of Elberfeld and their factory in Oberbruch in Dremmen near Aix-la-Chapelle, including the various raw materials, wood, cellulose, alkali cellulose and the cellulose-xantogenates produced by treatment with bisulphide of carbon and the viscose solution itself.

ACETYLCELLULOSE. *Cellit Films*: From acetylcellulose soluble in aceton, called cellit, the Farbenfabriken vorm. Friedr. Bayer and Co. first produced cinematograph films, but although they have the great advantage over those manufactured from nitro-cellulose in being non-inflammable, it has not been possible to introduce them generally. In all their properties the cellit films are equal to the old inflammable ones, yet the proprietors of moving picture theatres do not take them up because they fear the competition of the schools and the home where the cellit films would be largely used on account of their non-inflammability. The only help then would be such action by those in authority as to make it difficult to employ inflammable films and to facilitate the use of cellit films. There are prospects of such legislation at least in Germany, which would put an end to cinematograph fires with their great danger to life and property.

Non-Inflammable Celluloid (Cellon): The problem of manufacturing non-inflammable celluloid by mixing cellit with suitable camphor substitutes which burn difficultly or not at all may be considered as definitely solved. Eichengrün has simplified the manufacture to an extraordinary extent by showing that certain acetylcelluloses may be gelatinized in the same way as nitrocellulose. As is well known, nitrocellulose with camphor in the presence of a solvent yields a so-called "Solid solution," and even in the dried state may be easily cut or formed into sticks, tubes or threads. Cellit when treated in exactly the same way with appropriate camphor substitutes, can be converted into "cellon," the non-inflammable substitute for celluloid. Single blocks weighing 200 lbs. are already produced on a large scale which like celluloid, can be sawed, cut, and polished; when heated can be pressed or bent; and when subjected to steam at a high temperature can be drawn and molded. Compared with celluloid, cellon has the advantage of being more elastic, soft and ductile. It is therefore frequently used as a substitute for hard rubber, gutta percha, leather, etc. Cellon, in the form of a highly viscous, syrup-like solution, may be employed for coating fabrics, wood, paper, metal, etc., with a thick, enamel-like uniform and pliable surface. Thus patent leather, artificial leather, insulators, balloon covers, etc., may be produced. In France this varnish is already employed for enamelling aeroplanes. Objects made of this novel and widely useful material are to be found among the exhibits, being manufactured by the Rheinisch-Westfälische Sprengstoff Actien Gesellschaft in Cologne and the Société Industrielle de Celluloid in Paris.

Rubber: Finally, I will refer to one of the greatest successes and yet one of the most difficult problems of the chemical industry, viz; the production of synthetic rubber. I am proud of the fact that its production was successfully accomplished in the works which are under my management, and that I was able to follow every stage of this important discovery. Perhaps you would be interested to hear, although it is getting late, how the whole thing happened, especially as much that is untrue and misleading has appeared in the press during the last few weeks.

But first a few words about natural rubber. The old world

owes its knowledge of this substance to the new. This wonderful product became known in Europe shortly after Columbus discovered America. If I, coming from across the ocean, now bring you this colloid prepared there synthetically, I merely repay part of the debt which we owe America.

Hardly a generation ago, the southern part of this great American continent furnished the whole supply of the different kinds of rubber. Since then extensive plantations of rubber trees have been established in various tropical countries and their yield has grown so enormously that the old home of wild rubber will soon be thrust into the background. This is a matter which involves many millions; consequently a very serious economical problem confronts South America.

You all know that caoutchouc is made from the milky sap of numerous species of trees and shrubs and the grotesquely formed lianas by various coagulation processes, and that this product, on being suitably treated with sulphur or sulphur compounds, i.e. by vulcanization, acquires its valuable and characteristic properties. The synthetic method took quite a different route. By breaking up the very complex molecule which rubber doubtless possesses, by pyrogenetic processes, i.e., by dry distillation, a veritable maze of all kinds of gases, oils and resins was obtained, as well as a colorless fluid resembling benzine, to which the investigators gave the name "Isoprene." It was the French scientist Bouchardat who first expressed the belief that this isoprene, which is obtained in very small quantities and in an impure form by the dry distillation of caoutchouc, might be closely and intimately related to caoutchouc itself. This important question was then eagerly discussed for several decades by the scientists of all countries and opinions were sharply divided. As far back as the Eighties, the Englishman Tilden claimed to have prepared artificial rubber from isoprene by treatment with hydrochloric acid. But neither Tilden nor his assistants, though they worked strenuously for years, succeeded in repeating the experiments. Moreover, numerous other investigators were unable to confirm the results. Dr. Fritz Hofmann of the Farbenfabriken vorm. Friedr. Bayer and Co. is to be regarded as the real discoverer of synthetic rubber, for, by the application of

heat, he succeeded, in August, 1909, in polymerizing the isoprene molecules into the complex rubber molecule. Somewhat later Harries discovered independently another method of arriving at the same result. Everyone is now in a position to repeat this exceedingly simple experiment himself, but in order to confirm Hofmann's results, it is necessary to employ *pure* isoprene.

The practical value of this rubber, of which many samples are among the exhibits, has been tested by the highest authorities in this branch of the industry, whilst Professor Karl Harries, whose unremitting labors extending over many years, prepared the soil for Hofmann's synthesis, has carefully examined the chemical constitution of the substance.

Isoprene belongs to the butadienes. It was therefore to be assumed at the start that betamethylbutadiene would not hold a peculiar and isolated position amongst the butadienes in general. It was argued that other members of this interesting group of hydrocarbons would yield analogous and homologous rubbers on being heated. In the synthesis of products occurring in nature, there is always a possibility of producing such variations, and our endeavors to find out whether this was true in the case of rubber were crowned with success, for today several representatives of the new class of caoutchoucs possessing different properties are known and are being submitted to technical tests. Exact proof of the existence of the class of isomeric and homologous caoutchoucs was also first presented by Elberfeld.

To you who hear this account and see these beautiful specimens, the matter appears very simple, intelligible and clear. In reality, however, it was not so. The difficulties which have been overcome were great indeed and those which still remain to be surmounted, in order to produce a substance equal to para caoutchouc in quality and capable of competing with cheap plantation rubber costing only 2 marks per kilo, are still greater. But such difficulties do not intimidate the chemist and manufacturer; on the contrary, they spur them on to further efforts. The stone is rolling, and we will see to it that it reaches its destination. The end in view is this: that artificial rubber may soon play as important a role in the markets of the world as does natural rubber. The consumption of rubber is simply enormous.

Finished articles to the value of 3 milliard marks are manufactured every year, and the raw material from which they are made, calculated at the present market price of 12 marks per kilo, costs one milliard marks. Other tasks which the chemist has on hand shrink into insignificance compared with this gigantic problem. The laurel wreath will not adorn the brow of the wild dreamer but that of the scientist who, cool and persevering, pursues his way. The seed he sows ripens slowly, and though according to the statements in the press, all this is mere child's play and the problem has been solved, I leave it to your judgment whether this is true or not, like much that printer's ink patiently transfers to paper. I am right in the midst of this excitement. I have employed articles made of synthetic rubber, and for some time I have used automobile tires made of this material. Yet, if you ask me to answer you honestly and truly when synthetic rubber will bring the millions which prophets see in its exploitation, I must reply that I do not know. Surely not in the immediate future, although synthetic rubber will certainly appear on the market in a very short time. But I hope to live long enough to see Art triumph also here over Nature.

We are now at the end of our journey. We have flown not only over the field of Germany, but also over all other countries where the chemical industry is cultivated. We have taken a passing glance at the untiring striving for advance, the restless search for the hidden and unknown, the ceaseless efforts to acquire more technical knowledge as witnessed in the great laboratories and factories of our mighty and ever-growing industry. We will now guide our airship into the haven whence we set out and land where our co-workers have gathered from all the countries of the earth to recount whatever progress each has achieved, and to discuss, in public and private, the problems which have been solved and those which still await solution.

This is the purpose and aim of the Congresses of Applied Chemistry, and in this way they promote directly and indirectly the interests of our industry. But they also serve another purpose

—to spread far and wide knowledge of our great deeds. It is thus that they impress the importance of our science and the arts founded on it upon the public in general and especially upon those who have influence in social or official positions, so that our profession may advance equally with others, and so that the importance of the chemical industry and of those connected with it from an economic, hygienic and social standpoint may become better and better known.

That the effulgent light of this knowledge will also be diffused by the Eighth International Congress of Applied Chemistry is assured by the magnificent organization which our friends, the American Chemists, have provided, the skillful manner in which the affair has been conducted, the hospitable reception which has been extended to us, not only by our colleagues but by the people at large, and which is still awaiting us in our tours of inspection of the flourishing industry of America, in so many respects a model for others. For Chemical Science and the Chemical Industry the following words of Schiller are beautifully descriptive:

"Only the serious mind, undaunted by obstacles, can hear the murmuring of the hidden spring of Truth."

THE INDUSTRIAL RESOURCES AND OPPORTUNITIES OF THE SOUTH

THE INDUSTRIAL RESOURCES AND OPPORTUNITIES OF THE SOUTH

Only those who have stood upon the seashore and there endeavored conscientiously to place the Atlantic Ocean inside a quart bottle by the aid of a teaspoon will appreciate the temerity and difficulties involved in an attempt to present within the compass of a brief address the industrial potentialities of the South. Probably no one but a relative stranger to the South would make the attempt at all. Nevertheless we are all prone to overlook the obvious in our immediate surroundings and the visitor who looks upon them from a different standpoint with sympathetic interest and keen appreciation may sometimes point out new aspects in them and values before unrecognized. The man who views a mountain range from a distance may even trace its outlines and sense its trend better than those who dwell upon its slopes. So it happens that one whose knowledge of the South is in no way comparable to your own may hope, through your indulgence, to enlist your interest and possibly to turn your thought in new directions.

The awful spectacle of a world in arms which we are forced to contemplate to-day must recall with a peculiar vividness to many men and women north and south the horrors and desolation of another struggle which was concluded, happily as we all now believe, just fifty years ago. When we consider that the wealth of the whole United States in 1850 was estimated at a little more than \$7,000,000,000, and that the cost of the war to the South has been conservatively figured at \$4,000,000,000, we may gain some faint notion of the material burden under which the South slowly arose to work out her destiny.

The situation she then faced was one to daunt the stoutest hearts. It involved a reorganization of the whole economic and social structure in a land mourning the loss of the flower of its youth and manhood, with broken credit, capital destroyed, industry prostrate, and streams of immigration diverted. To the burdens of the Reconstruction period were added the paralyzing fallacies of the Greenback issue and the nation-wide disasters and stagnation of the panic of 1873, and the five lean years which followed. Not until 1880 did the South begin to come into her own.

In 1880 the agricultural capital of the South was $2,762,000,000, and the total value of its agricultural output $756,000,000. The cotton crop was 5,761,000 bales of which the South used 179,000 bales and the North 1,610,000. Only about $330,000,000 were invested in manufactures, the mineral output was $18,000,000, the railway mileage approximately 25,000, and the population 18,600,000. With these figures in our minds let us attempt the construction of a concept of the industrial South to-day.

The population of the South in 1912 had risen to 33,475,000, and the railway mileage to 90,930. The population of the whole United States in 1880 was about 50,000,000 and the total railway mileage 93,000. In general it may be said that the South to-day is in a far stronger position industrially than the entire country was in 1880. It cuts more lumber, mines nearly twice as much coal, produces nearly four times the petroleum, and nearly six times the spelter. It has more looms and spindles and a much larger investment in manufacturing plants. Its agricultural capital is greater and the products of its farms are worth fifty per cent more. It makes nearly as much pig iron and twice as much coke as the whole country produced only thirty-five years ago.

Agriculture is still and always will be the greatest business of the South and the backbone of its prosperity although even now the value of manufactured products exceeds by nearly $900,000,000 the revenue from its farms.

As all the world knows the South affords a peculiarly favorable habitat to the cotton plant and the 36,000,000 acres under cotton produce annually from 14,000,000 to 16,000,000 bales of the fiber, or about sixty-five per cent of the world's crop. In this connection it may be said in passing that chemists by developing methods for utilizing values in the cotton seed have added from $12 to $14 per bale, or perhaps $200,000,000 yearly to the value of this single crop, so that the seed alone is now worth nearly as much as the entire crop of 1860. Cotton and seed together constitute about thirty per cent of the total value of southern farm products, excluding live stock. The ultimate products of the cotton plant together constitute thirty per cent of the merchandise exports of the whole United States. The value of staple, linters, and seed in 1913 was $911,000,000. Corresponding values for 1914 were $704,000,000, so that the European war may fairly be said to have cost the South, on this one item, over $200,000,000.

Many years ago a certain café in New York attained a cheap but widespread notoriety by embedding in the mosaic of its floor a few hundred silver dollars. There are 600,000,000 acres in the South and nearly every one of them carries on its surface more dollars than the floor of that café. Upon 110,000,000 of these acres the South now raises crops valued at more than $3,000,000,000. From 1880 to 1910 agricultural capital increased from about $2,800,000,000 to nearly $11,000,000,000, or 296 per cent.

In spite of the proud preëminence of cotton in southern agriculture a considerable diversity of crops has already been established. Texas alone has raised 200,000,000 bushels of corn in a single year and the value of the 1913 corn crop in the South was $766,000,000. In that year the value of the hay raised was $111,000,000, wheat $95,000,000, and tobacco $72,000,000, with another $125,000,000 in oats, Irish and sweet potatoes, sugar cane, and citrus fruits. 20,000,000 head of cattle, 25,000,000 swine, and 9,000,000 sheep add their values to the wealth of southern farms.

Strangers to the South do not commonly think of this portion of our country as a manufacturing community. They may therefore well be surprised to learn that already the manufactures of the South greatly exceed in value the products of its farms and reach the stupendous total of more than $4,000,000,000. In the twenty-nine years from 1880 to 1909 the capital invested in the South in manufactures increased 900 per cent and the value of manufactured products 407 per cent. The census survey of the entire country enumerates 262 different lines of manufacture. Of these 236 are already carried on in the South. Sixty-five per cent of the new spindles installed in the United States since 1890 are in place in southern cotton mills which now operate over twelve million spindles and consume nearly three million bales of cotton, whereas the northern mills in 1913 used only two and one-half millions. Two southern states already manufacture more cotton than they raise. The value of cotton goods produced is nearly a quarter of a billion dollars. One seldom hears of southern flour and grist mills, yet their product reaches the striking total of $209,000,000.

The factory products of one southern state, Missouri, reached a value of $688,000,000 in 1912, which included nearly $50,000,000 in boots and shoes and corncob pipes to the number of 28,000,000. The value of Missouri manufactures to-day is probably nearly or quite equal to the total value of southern agricultural products in 1880.

West Virginia claims the largest pottery and largest glass factory in this country and the largest axe factory in the world.

In nine years, beginning with 1900 eleven southern manufacturing industries, including some of great importance, increased their annual output by amounts ranging from 259 per cent to 2380 per cent. The total increase in ninety-two leading industries was from $1,288,000,000 to $2,696,000,000, or 106 per cent. During the same period capital invested in factories rose in Texas from $64,000,000 to $217,000,000.

The total forest area of the South is estimated at

259,000,000 acres. That of Germany is about 35,000,000. In 1913 the whole United States cut 38,000,000,000 feet of lumber of which the South cut over 21,000,000,000, including 15,000,000,000 feet of yellow pine. One Louisiana sawmill cuts 1,000,000 feet of this wood a day. Eight years ago the site selected for this mill was in a stretch of virgin forest. To-day it stands upon the outskirts of the thriving and unusually attractive little city of Bogalusa with over ten thousand inhabitants, and stores, residences, and public buildings which would be the pride of many an older community of much greater size.

The outstanding predominance of yellow pine should not cause us to overlook the fact that of more than fifty woods manufactured into lumber in the United States the South cuts over forty. In case of ten of the more important of these fifty woods the cut of individual southern states ranks first.

The annual value of southern lumber is about $350,000,000, but the reported cut excludes so many primary wood products of large importance that at least another $100,000,000 must be added to represent their value and $25,000,000 more for naval stores.

Coal lies at the basis of civilization and its stored up energy is the present measure of man's command over nature. Excluding lignite the coal areas of the southern states amount to about 88,000 square miles or over fifty times the coal areas of Germany, seven times those of Great Britain, and twice those of all Europe including Russia. The South's present proved reserves of coal are estimated at 530,000,000,000 tons or twenty-five per cent more than the more thorough exploration of all European countries has disclosed — and these southern reserves comprise seventy-five per cent of all the coking coal in the United States. West Virginia alone has a far greater coal area than Great Britain and Germany combined and she has mined less than one-sixth of one per cent of the 150,000,000,000 tons beneath her surface. Nevertheless her 1912 output of 67,000,000 tons was fifty per cent more than all bituminous coal mined in the United States

in 1880. Alabama already stands next to Pennsylvania in coke production.

With coal, limestone, and iron ore closely adjacent within her borders Alabama has already demonstrated her ability to manufacture pig iron more cheaply than any other locality on earth and "he who has the iron will get the gold." Her present output of 2,000,000 tons is merely an earnest of her potentialities. The immediately available southern iron ores are estimated at 2,600,000,000 tons with even greater reserves of ores of lower grade. Together these constitute not less than fifty per cent of the total iron resources of the country.

It is doubtful if any American product is better known throughout the East than those tins of kerosene which bear the label of the Standard Oil Co. Our automobiles consume an amount of gasoline equivalent in volume to the water supply of a town of 40,000 inhabitants. The range of endeavor of Newfoundland fishermen is determined by its price and the flight of aëroplanes over the battlefields of Europe is measured by its supply. In 1890 the South produced less than half a million barrels of petroleum. In 1912 its output was 84,800,000 barrels. Passing by the great deposits of Louisiana and Texas, it may be pointed out that the oil production of Oklahoma alone in 1911 was 54,000,000 barrels.

Among these bounties of Nature with which the South has been so plenteously endowed few have greater potential values and none have been wasted more recklessly than natural gas. More than sixty per cent of the gas output of the country, or 290,000,000,000 feet, must now be credited to the South. From the standpoint of industrial utilization this is more than a billion feet per working day.

The relative cheapness of water power as compared to steam has determined in the North the location and development of many great manufacturing centers like Holyoke, Lowell, and Lawrence in Massachusetts, and Rumford Falls and Lewiston in Maine. The application of this power to electrochemical industries has made Niagara Falls the most interesting place on earth to chem-

ists. Cheap water power not only implies but insures the ultimate development of public utilities and the establishment of manufacturing plants within the radius which it may serve.

Seven years ago the United States Geological Survey estimated the minimum available power in eleven of the streams which have their headwaters in the southern Appalachian Mountains at 2,800,000 H.P. The estimate for all the streams of the South has been put at about 5,000,000 H.P. Only about one-fifth of this power has been developed and of this amount nearly 800,000 H.P. is in the five states of Alabama, Georgia, North Carolina, South Carolina, and Virginia. Georgia alone has available 500,000 H.P.

The lavishness with which Nature has bestowed her gifts upon the South is nowhere more apparent than in the extraordinary variety and range of what may be termed the secondary mineral resources of this fortunate section of our country. An output of $5,800 worth of diamonds per week of the best South African quality in Pike County, Arkansas, is interesting and promises to become spectacular, but it shrinks to insignificance before many other southern mineral products. The whole country knows of the annual shipment of 8,000,000 boxes of Florida oranges and grapefruit, but relatively few of us give thought to the 3,000,000 tons of the infinitely more important phosphate rock which Florida produces. This is about four-fifths of the country's output, practically all of which now comes from the South.

Portland cement requires for its manufacture an assured supply of limestone and clay or shale adjacent to cheap fuel. Nowhere are these conditions met more fully or more generally than in the South. As a result its development of the manufacture of Portland cement has become one of the industrial miracles of the world. In 1890 the production for the whole United States was less than 400,000 barrels. In 1911 the output of cement in the southern states alone was nearly 11,000,000 barrels.

The South has inexhaustible supplies of clays which exhibit every desirable range of quality. There are clays in any amount desired for the making of common brick

and tiles, cheap pottery and drain pipe, terra cotta and paving brick, and prodigal amounts of the finer white plastic clays and kaolins for china and the purposes of paper making. The production of Fuller's Earth is almost exclusively a Southern industry.

The South is equally fortunate in its endless stores of sand and gravel, road material, and building stones. The latter range from the superb Georgia marbles and the granite of Stone Mountain near Atlanta through every variety and quality to meet all structural demands.

Immense deposits of gypsum occur in several southern states, and ochres, mica, graphite, barytes, and corundum are among the well known mineral products of the South.

The history of industrial chemistry is a record replete with romance and one of its best known stories is that which chronicles the development of the aluminum industry. In 1855 the metal cost $90 a pound; the Castner process brought the price to $4 in 1889. Then Hall in America and Heroult in Europe simultaneously developed the process which permits its cheap production by electrolyzing alumina in a fused bath of cryolite. Bauxite is an impure alumina and has become the chief source of the metal. Arkansas leads in the production of bauxite but Georgia, Alabama, and Tennessee contribute largely to the growing demands.

Another romance of chemical achievement is that which tells the story of the sulphur mines in Calcasieu Parish, Louisiana. There sulphur in inexhaustible amounts lies 1,000 feet below the surface and under 500 feet of quicksands. An Austrian company, a French company, and many American companies had tried in many ingenious ways to work this deposit, but each had failed. Frasch solved the problem by forcing superheated water down a boring and pumping out the melted sulphur through an inner tube. To-day Louisiana holds easily within her hands the sulphur markets of the world and supplies one half the world's consumption.

Sulphur, as the direct source of sulphuric acid, constitutes the foundation of all chemical industries. The keystone

of the structure is common salt. This the South bountifully supplies at Avery's Island, also in Louisiana, and in the salt wells of Oklahoma and West Virginia.

The largest sulphuric acid plant in the world is at Ducktown, Tennessee, but the striking feature of the installation which holds this record is that the acid is made from smelter fume, which commonly in other plants goes only to create a nuisance. The copper production, which is the primary output of the plant, is over 18,000,000 pounds per year. The largest copper refining plant in the world is at Patapsco, Maryland, with an annual production of 200,000,000 pounds.

In 1911, forty-two per cent of the lead output of the country came from the South and forty-one per cent of the zinc production. The value of Missouri zinc alone was $14,000,000. The largest pyrites producing plant in the whole country is in Louisa County, Virginia.

There are produced in the United States fifty-seven useful minerals. Of these every one is mined in the South except platinum and borax.

We have reviewed in the most casual and disjointed manner the immediate achievements and demonstrated resources of the South in those things which make for industrial preëminence. All these figures are well known to you. They have been set forth time and again in the publications of the Federal government and of your own states, and reiterated with compelling emphasis and illuminating comment by that apostle of southern achievement and prosperity,—the Manufacturers Record. The aggregate of these stupendous figures represents an achievement and a heritage of which any people may well be proud, but the community whose eyes are filled with a vision of the future should take measure not of its successes but of its failures. What are the failures to be charged against the South?

First of all there is the stupendous failure of its agriculture. In 1909 only about eighteen per cent of the total area of the South was tilled, whereas seventy-five per cent is available for tilled crops. What is more to the point the 110,000,000 acres which were tilled were tilled badly. Upon

35,000,000 acres the South raises as a maximum 16,000,000 bales of cotton. Less than one-half bale per acre. In some localities the yield shrinks even to 132 pounds per acre. As compared with this Georgia has raised upon 2,500 acres 2,700 bales, while as much as 2.38 bales has been raised upon a single acre in Texas. Little more than deeper ploughing and intelligent fertilization is required to double the present cotton crop or to produce the 1914 crop upon half the present acreage, leaving 18,000,000 acres available for corn and other crops. In one southern state 232 bushels of corn have been raised on a single acre; in another 13 acres of lettuce have sold for $12,000, and in a third 5,000 acres of cabbage have yielded $80,000, and 2,000 acres $600,000 worth of cucumbers. In the same state 145,000,000 cabbage plants were started upon 346 acres and exported to other states to complete their growth. A single acre of Florida celery has paid $1,500 in freight to the railroad. North Carolina, which shipped 1,600 carloads of strawberries from Wilmington, in one season, reports 15,000,000 acres within the state upon which no agricultural improvements have been made. Alabama still buys largely of western grain, provisions, and even hay, while Arkansas bought $80,000,000 worth of foodstuffs last year.

Next perhaps in importance is the failure of southern lumbering which is one of the most wasteful operations conducted on the whole broad face of the earth. Upon a cut of 15,000,000,000 feet of yellow pine the South wastes not less than 30,000,000,000 feet, which intelligently utilized as raw material should yield ten times the profit derived from lumbering.

For every ton of coal mined in the South, or for that matter in the country, one-half a ton is wasted or left underground in such condition that it can probably never be recovered.

The most atrocious and unnecessary wastes which have attended the development of any resource of our country have been those which have accompanied the exploitation of natural gas. As to these the South is no more culpable than other portions of our country upon which this ex-

traordinary boon of nature was conferred. Nevertheless it may interest you as southern men who would conserve the resources of your birthright to know that the waste of gas in the Oklahoma fields alone has been as high as 150,000,000,000 cubic feet a year, and is now annually not less than 25,000,000,000 cubic feet. The time is fast approaching when natural gas will have its value determined by the number and value of the synthetic products which chemists are able to derive from its several components. For the present it may suffice to point out that every 100,000,000 cubic feet of natural gas represents on the basis of a ten hour day 588,000 H.P., if consumed in a fair gas engine on fluctuating load averaging fifty per cent of rated capacity. West Virginia is now the largest producer of natural gas in the country; and the special disability under which the South now labors is exemplified by the fact that a very large part if not the major portion of the gas originating in West Virginia is piped outside the state and used for the generation of heat and light and power elsewhere.

It has already been pointed out that the South contains over fifty per cent of the total iron resources of the country. Nevertheless it produces only twelve and one-half per cent of the pig iron made and consumes not over 150 pounds per capita while the whole country consumes 650 pounds. Here again we have before us the fundamental difficulty which confronts the South. A ton of iron ore shipped as ore returns only $2 and provides less than one day's work for one man. If shipped as stoves it returns $40 and has provided a day's work for ten men. The South has been selling raw materials. It should sell brain values and labor values.

Owing to its later advent as a large producer and its relatively more general introduction of by-product coke ovens the South has been less wasteful than the North of the ammonia values in its coal. It will probably never be possible to recover more than a moderate proportion of these values but the extent of the problem in the whole country may be indicated by the fact that the total volatile

ammonia in the coal mined annually in the United States would be worth, at $60 per ton for ammonia sulphate, over $300,000,000. We save less than $4,000,000. In Germany four-fifths of all coke is made in by-product ovens, in the United States only about one-sixth.

In the Florida pebble field the tonnage of phosphate rock wasted is two or three times the total tonnage saved. The waste occurs mainly through the washing away of fine particles by the water used in mining and for cleaning the larger aggregates. In the Tennessee field there is relatively much less waste.

The wastes in zinc mining and smelting constitute another heavy drain upon your resources. Less than fifty per cent of the zinc in the mines ever reaches the form of spelter.

Many other comparable examples of the prodigal use or utter waste of valuable raw material might easily be cited though perhaps to no advantage at this time. There are signs that the era of thoughtless or wilful extravagance is passing. Means of production, methods of practice, and systems of organization which have been worked out painfully and at great cost elsewhere are being gradually adopted in the South but a more general appreciation of their advantages may well be urged.

An excellent example of intelligent conservation is afforded by the great pulp mill at Canton, North Carolina. Formerly the spent chips from the chestnut extract plants were burned. Now they are boiled in caustic soda and converted into high grade pulp and paper.

All visitors to the South who have been so fortunate as to partake of the hospitality of southern homes cherish always thereafter a warm appreciation of the grace and courtesy of southern life. The charm of New Orleans is proverbial and the metropolitan aspect and quality of many southern cities like Jacksonville and Atlanta strike the observer at once. One may nevertheless be permitted to suggest that the South would gain immeasurably by giving to a larger proportion of its smaller towns and country places that atmosphere of trig neatness and comfortable

prosperity which characterizes so many of the older villages of Massachusetts and Vermont and reflects the pleasantness of life in them. The South is also greatly handicapped by the general quality of its roads. Only about 60,000 miles out of 850,000 have ever been improved.

One of the greatest of the relatively undeveloped potential industrial assets of the South is undoubtedly the negro. The negro population in the southern states is about 10,000,000, and by the efficiency of the units of that population the prosperity of the South is profoundly affected. Many negro farmers are now raising from 30 to 60 bushels of corn per acre where formerly they raised from 5 to 15 bushels. Where they produced from 150 to 200 pounds of lint cotton per acre many now secure 250 to 600 pounds. Nevertheless, a demonstration agent of the Department of Agriculture has recently found negroes farming almost entirely by hand. Three persons carried on the planting of the grain; the first would dig a hole for the seed, the second would plant it and the third would cover it. He introduced the use of the plow in this twentieth century.

Scarcely any work carried on in the South to-day is more truly constructive or fraught with greater ultimate possibilities than that which goes forward at Tuskegee and in those other institutions of which it is the type. Since its foundation approximately 9000 young negro men and women have received two years of industrial training. They entered with an average earning capacity of about $100 per year. Their earnings after training have averaged $700, which by the way is above the average for doctors and lawyers in Massachusetts. The average length of time that these 9000 students have been out is fourteen years and in that time their estimated earnings have been $88,200,000. Deduct from this the $12,600,000 which they might have earned without their special training and the already accrued value of that training which it cost Tuskegee $1,467,000 to impart is $75,600,000. Is there any more profitable business in which the South can engage?

We have given a brief consideration to the imperial resources of the potential South and have sketched in a few high lights in an attempt to picture something of the South's amazing progress and achievement. Let us turn our attention to the trend and goal of her development.

The first of her problems would seem to be the organization of rural life to make it richer, more satisfying, more profitable and pleasanter. It is bound up with the problem of the reorganization of southern agriculture. The South has really not begun to farm. To prove the thesis one has only to turn to the results secured by agricultural demonstrators, demonstration farms, boys' clubs, the girls' tomato clubs, the MacRae experiment in North Carolina and the output of truck farms under scientific control in many southern states. There is not a single southern crop which cannot easily be increased five hundred per cent. For two per cent of the value of a single potential crop 20,000,000 acres of swamp land in Louisiana could be drained and the South's output of cotton doubled. There are no more fertile lands on earth than the Louisiana lowlands, and Louisiana, which might have been in ages past another Egypt, should become another and a greater Holland, and in Holland lands potentially less productive sell for $500 to $1,500 per acre. Tennessee has a swamp area of 1,000,000 acres. Along the Atlantic coast are 25,000,000 acres of sandy loam, ideally adapted to intensive farming. Texas has an area of 170,000,000 acres, greater by 55,000 square miles than either France or Germany, but less than 30,000,000 acres are yet improved. It now carries over ten million head of livestock while Texas bees are worth $5,000,000, and produce each year honey and comb to the value of $5,000,000. It pays to keep a bee in Texas.

One yields in passing to the temptation to refer to the camphor trees of Florida and Texas and the date palms profitably grown on the islands near the Texas coast. But details and figures merely obscure the broad and basic proposition, which is that the agricultural possibilities of the South are almost beyond conception and that in their

development can profitably be employed all that enterprise, capital, and science can supply for many years. Diversified, intensive agriculture by individual endeavor, corporation farming, and community effort under scientific direction and control will find full scope and reap harvests unthought of now.

Foremost among the industrial problems of the South would seem to be the suppression of wastes, the vastly greater development of labor values in its products and the keeping at home of money now needlessly spent elsewhere. The South has been too generally content with shipping crude materials and primary products and too ready to accept from other sections the things which it might better produce at home.

For gigantic wastes which may immediately be utilized to the enormous profit of the South no industry is comparable to the lumbering of yellow pine. Our studies have shown that in Louisiana at least under exceptionally able management the products of the average yellow pine tree may be classified as follows: Needles and twigs, 2.25 per cent; limbs under 3 inches, 2.54 per cent; cord wood, 6.42 per cent; pulp wood, 4.54 per cent; red and rotten, 8.05 per cent; slabs, edgings, and trimmings, 18.07 per cent; sawdust and shavings, 17.62 per cent; lightwood, .61 per cent; stump, 6.48 per cent; lath, 1.39 per cent; shingles, .06 per cent; and finally lumber and box shooks, 31.97 per cent.

Two-thirds of the tree is at present wasted either as litter in the field or as mill waste. And $3 a thousand is a good profit on lumber!

While northern paper mills are paying on the average $18.37 for the wood to make a ton of paper the South is throwing away tens of thousands of cords of pulp wood every day, only a cord and a half of which is needed to make a ton of Kraft paper worth $70. The ultimate development of a vast paper industry in the South is assured but as a recent editorial in the "New Orleans Item" pointed out: "Great industries do not spring from great opportunities. They result from the initiative of some individual. The captain of industry may create an in-

dustrial empire in a desert and bring his materials hundreds of miles from spots far more favored by nature than is their destination. We in Louisiana lack industrial empire because we lack captains of industry."

The recently culminating discoveries in a century-long research have proved that twenty gallons of 95 per cent ethyl alcohol, that is, not wood alcohol but the alcohol commonly produced from grain, may be obtained from a cord of yellow pine sawdust or hogged waste. From a bushel of corn worth say eighty cents only 2¼ gallons are obtained. Such difficulties as have attended the initial large scale operation of this process are certain to be overcome, and have in fact for the most part already been surmounted. Cheap industrial alcohol made in enormous volume from yellow pine waste and available for motor fuel, lighting, heating, and a thousand miscellaneous applications in the arts is a certainty of the future.

In Georgia a great plant for the production of naval stores is shut down primarily, it is claimed, because the annual loss of solvent represented twenty-three per cent of the entire plant investment. New processes promise a solvent loss of less than two per cent.

Several types of gas producer are now operating profitably on wood waste. New methods of controlled distillation have been developed and applied to wood and it has been proved both by the Forest Service and our own laboratory that turpentine and rosin may be profitably extracted from stumps and lightwood by processes which permit the manufacture of paper from the extracted chips. The production of lumber in the South will ultimately become a mere incident in the business of lumbering. No longer then will logging tramways be pulled up the moment the saw logs on the tract have been removed. They will stay until the tract is cleared of cord wood, pulp wood, lightwood, stumps, and saw logs. The cleared land will be devoted to grazing or to farming under the stimulus of demonstration farms or corporation management and the lumber mill become the center of a whole group of highly profitably industrial activities.

Less than thirty per cent of the lumber produced in any southern state receives any further industrial handling in the state of origin. Cotton seed oil is shipped to Chicago and to Berlin, N.H., to be hydrogenated and converted into lard and butter substitutes. Bauxite is sold for $5 a ton to be subjected elsewhere to the purifying treatment which raises its value to $60. The South will one day benefit enormously by a cheap process of producing alumina direct from clay. It will give new values to southern clay beds and to southern water powers and transfer the aluminum industry to this section. It does not appear however that any effort is being made in the southern states to develop such a process.

There are at Webster, N.C., millions of tons of low grade nickel ore awaiting only a commercial method of extraction. True halloysite in large quantities occurs on Taylor's Mountain, near Gore, Ga. It contains thirty to thirty-five per cent of alumina, said to be soluble in dilute sulphuric acid to form a clean white alum cake almost wholly free from iron and silica. If these claims can be established there is the basis for a large industry. A single northern paper company consumes 12,000,000 pounds of alum a year.

The Snelling process and the more recent Rittman process seem to point to important new developments in the technology of petroleum. They are likely to add new values to this material and to afford the basis of new industries.

No locality in the United States and perhaps none in the world presents such advantages for the establishment of the great basic chemical industries as Louisiana. Here in close juxtaposition are found cheap salt, even cheaper sulphur, gas, oil, rosin, turpentine, and wood waste while nearby are the coal and minerals of Arkansas and Alabama.

It is noteworthy in view of the extraordinary opportunities for chemical development presented by the South that in the southern states are to be found only about ten per cent of the chemists of the country as represented

by the membership of the American Chemical Society. The Society has 7,180 members, of whom only 746 are in the entire South, whereas New York has 1,186 members, Pennsylvania 656, Massachusetts 511. What one chemist can do for the South has been shown by Frasch in Louisiana, by Wesson wherever cotton seed oil is made, and by our distinguished president Dr. Herty in the conservation of turpentine and increase of yields.

Fragmentary and utterly inadequate as this attempted presentation of southern resources has proved to be it will have served its purpose if it has brought freshly home to some of you who live in this supremely favored section of our country the responsibility for individual initiative imposed upon you. Opportunity implies responsibility. Gentlemen, you are heirs to an imperial inheritance and its responsibilities are yours.

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CONTRIBUTIONS OF CHEMISTRY TO THE SCIENCE AND ART OF MEDICINE[1]

AT the last two meetings of this Society the general sessions have been devoted chiefly to symposia upon the contributions of the chemist to the varied phases of our American industrial development. Such emphasis is both timely and well merited. But I am impressed that this record of achievement should not be closed without some consideration of the contributions of chemistry to the science and useful art of medicine. The opportunity seems likewise propitious for some suggestions as to means by which future contributions in this direction may be increased in number and in value.

The *science* of medicine consists in the knowledge of the normal processes of the human body (physiology) and of the nature and causes of abnormal deviations (pathology). The *art* of medicine includes the prevention of such deviations (hygiene), their identification (diagnosis) and their correction or alleviation by therapeutic or surgical treatment. For its present state of development each of these branches owes much to the contributions of chemistry.

Since Lavoisier's demonstration of the identity of respiration with combustion the chemist has gone step by step with the physiologist in elucidating the normal operations of the

[1] Presented to the Division of Biological Chemistry of the American Chemical Society at the spring meeting at Champaign, Ill., April 17–21, 1916.

first internal combustion engine. Chemical structure of inanimate carbohydrates, lipins and proteins sheds reflected light upon the reactions and structure of living protoplasm. Colloidal chemistry, catalysis and the laws of chemical dynamics furnish all that we know of those servants of the cells, the enzymes. A new constituent of the blood is recognized to-day and to-morrow we have a new theory of metabolism. Thermochemistry is the foundation of nutrition and dietetics. The occultism of biogenesis, growth and the internal secretions is giving way before the calorimeter and the differential equation. In a word, the whole datum of physiological chemistry is a contribution to physiology and hence to the science of medicine; that much of it yet lacks practical application is no discredit to the contributor.

So much yet remains to be done in the field of chemical pathology that we are sometimes inclined to disparage past achievements. But these are not inconsiderable. In edema, concretions, diabetes and other conditions of acidosis, pathological variations in metabolism in fever, and in numerous other directions substantial gains have been recorded. Uric acid has been found not guilty of most of the offenses charged in the earlier indictments—and part of the responsibility for gout must be borne by as complete a chemical abstraction as tautomerism. But, by all odds, the greatest progress in the field of pathology is the widening recognition that in the future the important advances must be made by the chemical rather than by the histological route.

These contributions of chemistry to the science of medicine are for the most part distinctly modern. Far earlier were many of those to the *art*. Paracelsus gave chemistry a practical object as it emerged from the clouds of alchemy when he declared that "the object of chemistry is not to make gold, but to pre-

pare medicines." In England, to-day, the drug store is the "Chemist's Shop," and those are not lacking in this country to whom the term chemist has a similar significance. Both are the spontaneous acknowledgment of the services of the chemist in supplying these tools of the physician. For if Paracelsus, Franciscus Sylvius and their followers of the iatrochemical school failed in their effort to develop chemistry simply as an adjunct to medicine they planted the seed which through many generations have brought forth Liebig's chloral, Ehrlich's salvarsan and the host of other synthetics which make up most of the materia medica of to-day.

The development in synthetic drugs which has followed the recognition of a connection between chemical structure and pharmacological action is a fascinating story; less, possibly, on account of actual results than because of the tantalizing probabilities. But with the establishment of the definite effects of at least some configurations and a measurement of the mutual influence of different radicals have come practical results. Guided by this information, old remedies have been improved by blocking the groups responsible for secondary effects or entirely replaced by better ones constructed to specifications. At the same time experimental pharmacology has been stimulated with the result that the modern physician has at command, for producing almost any desired effect, a variety of drugs of great reliability.

But internal therapy does not exhaust the resources of treatment and if synthetic chemistry has done much for the former it has done still more for surgery and the surgical specialties. Anesthesia and asepsis are the pillars of these structures—and the stones of the pillars are the synthetics ether, chloroform, iodoform.

Strangely enough, diagnosis is the last branch of medicine to which applied chemistry

has brought substantial benefit. To be sure we have had for many years an attempt at diagnosis by means of qualitative tests.[2] The urinalysis consisting only of qualitative tests for sugar and albumin is worth just as much as the feel-your-pulse, see-your-tongue, give-you-calomel variety of clinical diagnosis and treatment—just as much and no more. The essentials of progress may be a slow and steady growth, but the results usually appear by spurts and in response to some particular incentive. In this case the impetus was furnished by the new methods of blood and urine analysis, introduced by Folin and his co-workers, which in a short time have found such wide application. Nitrogen partition in the urine and retention in the blood; urobilin index of erythrocyte destruction; differentiation and prognosis in renal and cardiac conditions; sugar and acetone elimination in diabetes; hydrogen ion concentration of the blood in other conditions of acidosis—these are but types of the applications of quantitative chemistry to clinical diagnosis. Scarcely a month in which the journals fail to report another.

In this résumé no claim is made to completeness—still less to originality—of data. But it is hoped that from a somewhat panoramic view there may be caught a conception of the truly basal relationship of chemistry to medicine. It is for this collective concept that I bespeak the consideration which it has received of few chemists and still fewer physicians. To be sure, chemistry has long occupied a more or less perfunctory position in the curricula of medical colleges—becoming rather more than less perfunctory as the actual preparation of medicines, its most

[2] "As long as only qualitative methods are used in a branch of science, this can not rise to a higher stage than the descriptive one. Our knowledge is then very limited, although it may be very useful."
—*Arrhenius.*

clearly recognized application, passed out of the hands of medical men. And chemistry is one of the subjects in which examination is required by official licensing boards. But it would require a most gifted intelligence to be able to deduce from the adventitious subject-matter of most of these examinations any suggestion that chemistry is a fundamental part of medicine rather than some extraneous attachment.

Let me explain what I mean by perfunctory position in the medical curriculum. Until the very recent general upheaval, medical instruction in all branches left much to be desired (to be conservative in expression). Rather than an exception to this statement, the old so-called "medical chemistry" was a glaring case in point. Crowded with descriptions of natural occurrences and methods of preparation of drugs, indications, effects and dosage, clinical symptoms of poisons and their laboratory detection—so much was usurped from the provinces of pharmacy, materia medica, pharmacology and therapeutics that little space was left even in the ponderous "Textbooks of Medical Chemistry" for references to fundamental chemical principles. When included at all these latter were carefully segregated within the paragraphs of their original mention—paragraphs which could be omitted quite as easily as those on the oxides of iodine without impairment to the continuity of the text. And in practise it would appear that these paragraphs on chemical principles were omitted with even greater facility.

We may well congratulate ourselves that "all that's put behind us," far away if not long ago. Instruction in chemistry in the medical colleges is now exclusively in the charge of full-salaried teachers, most of whom are trained chemists. Matters extraneous to chemistry are no longer allowed to preempt the place which belongs to the fundamentals

of chemical theory and the present-day courses in chemistry, as given in most medical colleges, are of quite the same degree of excellence as those in other professional or academic institutions.

It is satisfying to regard this improvement, but facts are not wanting which raise other questions. May we still be lacking somewhat of the highest possible efficiency? In the Standards of the Council of Medical Education of the American Medical Association, defining the "Essentials of an Acceptable Medical College," this dictum is laid down, "Non-medical men should be selected as teachers in medical schools only under exceptional circumstances and only because medical men of equal special capacity are not available." The obvious advantage sought is the wider point of view of men trained to the practical applications of their subjects to other branches of medicine and able to direct the minds of students to these interrelationships. There is no department of instruction in which this advice of the Council has been so consistently disregarded as in the selection of chemistry teachers—and for the very good reason indicated, that "medical men of equal special capacity" were not (and are not) available. Medical instruction in chemistry is, therefore, for the most part in the hands of men adequately enough trained in chemistry but without formal education in medicine. As one of that very class, I venture to raise the question as to whether we have always sufficient catholicity. Is it not possible that we sometimes overlook the fact that we are training men to be physicians, not chemists? In our very righteous indignation at the inefficiency of the old "medical chemistry" may we not have swung the pendulum a little too far away from the point of practical contact?

To the last question it may be replied with perfect logic that when we have laid an ade-

quate foundation of sound theory it is for the physiologist, the pathologist and the internist to build upon it according to the particular needs of his subject. But, like the gas laws, this logic applies strictly only under ideal conditions. As a practical fact the pathologists, internists, etc., concerned are not infrequently men who have succeeded less on account of any knowledge of chemical principles than in spite of the handicap of their inadequate instruction in that subject. Most of us have known chemists, the great men of a passing generation, who having passed middle age before the advent of certain theories were entirely unable to use them in their reasoning although according formal acceptance. It were hardly fair to prescribe a more rigid requirement for our medical teachers of the present, though we may expect much more of those now in the making. In the meanwhile, shall the student be allowed to miss much which is essential because the chemistry teacher prefers to draw about himself the white mantle of pure science and pass by on the other side?

Another question occurs. By inference there has already been suggested a need for teachers trained both in chemistry and in medicine. The large number of published researches by "John Doe, Ph.D., and James Smith, M.D." suggests another field of usefulness for the man who can unite the training indicated by these two degrees, while the increased application of chemical analyses to clinical diagnosis is a third factor in creating a demand for such preparation. The last factor is worthy of some special consideration. This increased demand for chemical data in diagnosis is already marked, but it has only commenced. There must be men to do the work—and the practician is excluded. The methods concerned are quantitative and their usefulness depends upon the accuracy of the results.

Even assuming the possibility of developing a quantitative conscience in a medical student within the available time, analytical efficiency can not be maintained by sporadic efforts—and the maintenance of regular quantitative work is incompatible with the practise of medicine. The requisite skill can be provided only by chemically trained men who give it their regular attention, and this is the way it is actually working out. The movement toward concentrating medical practise in hospitals is already well under way; an eminent authority has predicted that it will soon become universal. Already the hospitals are providing their corps of clinical chemists. Is it not time to make some special educational provision for the particular kind of combined training which will peculiarly fit men to discharge the functions of teaching, research and clinical control which have been indicated?

It may be suggested that adequate preparation for such work may be secured even now by pursuing the courses leading to the Ph.D. degree in chemistry and subsequently going on to the M.D. A few men do this and we recognize the *a priori* advantages which they possess over those who have only the one degree. But it is not economically sound to advocate this regimen for all who would so qualify themselves. Of the four years required for the medical degree (already it is five in those institutions which set the standards for to-morrow) more than half the time is devoted to the subjects of anatomy, surgery, obstetrics and minor allied subjects to which present or prospective chemical methods are only remotely related. It would appear both desirable and feasible to provide in our medical schools (or some of them) a special course for men already thoroughly trained in chemistry. Within two years could be compassed intensive courses in biology, physiology, ad-

vanced physiological chemistry, pathology, bacteriology and internal medicine with very brief attention to such portions of other branches as might appear desirable. With a bachelor's degree including as much chemistry as is now obtainable would it not be possible to arrange such a special course as suggested and, following this with a year of research, grant at the end of seven years the Ph.D., D.Sc., or a new degree of equal dignity?

A few years ago the Division of Organic Chemistry held a symposium upon methods of teaching that subject. If there are enough of the members of this Biochemical Division who are interested in the suggestions raised, or in allied considerations, it might be of advantage to provide at some future meeting for a similar free discussion of the whole matter. Out of such a frank canvassing of the situation there should come results which would enable the chemistry of the future to offer even more substantial contributions than the chemistry of the past has made to the science and art of medicine.

L. Junius Desha

Memphis, Tenn.

The Relation of Research to Industrial Development

1917

Address before Canadian Manufacturers Association, Toronto.

By Arthur D. Little.

THE German alarm clock, to which my associate, Mr. H. E. Howe, referred in a recent address, has so thoroughly awakened and aroused the whole world to the vital necessity of applying the scientific method in business and governmental affairs, if prosperity and even national security are to be assured to any people, that it has become the duty and privilege of those of us who are familiar with this method and its application to preach the gospel of Research.

I therefore esteem myself particularly fortunate in having the opportunity which you have given me to-night to carry the message to such a representative and, I am sure, sympathetic audience of Canadian business men and manufacturers.

I assume with confidence that few if any of you have come here in the attitude of mind of that American steel maker in a small and remote town who, years ago, when his directors decided that their interests might be furthered if he were to employ a chemist, wrote back:

"Send down one who can play the violin. We can stand his damned nonsense in the daytime if he will amuse us in the evening."

I do not play the violin myself and I have not come here merely to amuse you. I have come here because I believe that I carry a message of supreme importance to each one of you, a message which not only concerns your individual prosperity but which is of vital import in the development and security of the Dominion.

It is usually regarded as unprofitable to speculate on what might have happened if your uncle had been your

aunt, but I feel that we may justifiably devote a moment to the consideration of where we would now stand in the event of that always interesting possibility.

The railway, as it serves you, is not the casual invention of Stevenson. It is the product of many decades of industrial research by Bessemer, Westinghouse, Pullman; by Dr. Dudley, who standardized its materials and supplies, and by countless chemists, engineers, mathematicians and physicists whose contributions to the common stock of knowledge made possible the development of its equipment, in at least as real a sense as it is the creation of the great organizers, audacious capitalists, and wise executives with whom its development is commonly associated in the public mind.

The telegraph as it came from the hands of Morse was a feeble and restricted means of communication. It carries the burden placed upon it by the business world to-day only because it embodies the results of protracted research by Wheatstone, Siemens, Stearns, Edison, Murray, and Rowland, which have many times multiplied the working capacity and operating length of telegraph lines.

The telephone, although initially a product of the most refined research, was when first given to the world by Bell little more than a scientific curiosity, as halting and uncertain in its speech as a child of three. To-day for the purpose of a conference it brings the people of a continent into one room and even carries the human voice from New York to Honolulu because it has passed through the laboratories of Berliner, Edison, Hughes, Blake, Hennings, and Carty, where in each instance new possibilities and powers have been bestowed upon it by intensive and prolonged research. Wonderful and seemingly perfect as the instrument is to-day, the American Telephone and Telegraph Co. finds it profitable to authorize its chief engineer, Mr. J. J. Carty, to expend for industrial research a greater sum than any other man in the world has at his disposal for such purpose.

The silent dynamo, instinct with power, supplies the current which lights our streets and homes and factories, drives our machinery, fires electric furnaces, creates new products in electrolytic cells, and is our ready and ever willing servant responding in countless ways to our demands. It so serves us only because Faraday by refined research stimulated and directed by the scientific imagination at its best, developed the underlying principles on which its operation depends.

The ocean steamship from wireless to propeller is a microcosm of the results of research without which it would be a scow. The harvester is the embodiment of years of systematic experiment.

Coming back now to our uncle and our aunt, I ask you to consider what would be the value of corner lots in Winnipeg, of mines in Sudbury, of farms in Saskatchewan, of waterpower on the Shawinigan, of forests in Quebec, of manufacturing plants anywhere in the Dominion, without these aids to industry? Where would your own business be without them? Is it not evident that modern industry is so broadly based and so intimately dependent upon the results of research that in their absence it could not exist a day?

I challenge you to name a business from shoe blacking to banking which is not vitally interested in the application of research results. In the earlier days of shoe blacking Bixby's paste and Day & Martin's liquid sufficed for all demands of the most exacting customers of the peripatetic polisher of shoes. The modern boot black applies a first coat, the formula for which has been worked out in the laboratory, and finishes off with a wax emulsion prepared in accordance with the latest teachings of the chemistry of colloids. He has a gum tragacanth paste for cleaning tan shoes and a tan paste appropriately colored by synthetic dyes for the polishing, something else for patent leathers, and Blanco for white shoes. He often styles himself "Professor," especially if he is colored. He works in a parlor or emporium and if the emporium bestows its benefits upon ladies it carries green polishes for green shoes, red polishes for red shoes, bronze polishes for bronze shoes — something, in fact, for each of the bewildering variety of shoes which adds so much to the interest of life just at this time. I don't think any boot blacks now use Day & Martin's blacking on white shoes, but some manufacturers do. Of course I do not mean Canadian manufacturers. But here are the statistics which prove it as regards some manufacturers in the United States.

There are in the United States over 250,000 corporations. Over 100,000 of them report no net income whatsoever. Ninety thousand make less than $5,000 a year. Only 60,000 make $5,000 a year or more. Making all allowances for lack of capital, bad credits, and all the other commonly recognized causes of industrial disaster, I do not hesitate to say without fear of successful contradiction that the

chief cause for this amazing and discreditable showing is due to the failure of small manufacturers to utilize that vast body of organized knowledge which the research of the last one hundred years has placed within their reach.

This is merely reiterating what was said years ago by that distinguished Canadian who has done more than anybody else to spread the gospel of industrial research in the United States, Dr. Robert Kennedy Duncan, the founder of the Mellon Institute at Pittsburg. In his "Chemistry of Commerce," a book which I can highly recommend to all of you, Dr. Duncan says: "The small manufacturer who is swept out of existence will often wonder why. He will ascribe it to the economy of large scale operations, or business intrigues or what not, never knowing that his disaster was due to the application of pure science that the trust organizations and large manufacturers already are beginning to appreciate."

To this may well be added these words of J. J. Carty, the world's greatest telephone engineer:

"In the present state of the world's development there is nothing which can do more to advance American industry than the adoption by our manufacturers generally of industrial research conducted on scientific principles. . . . Those who are the first to avail themselves of the benefits of industrial research will obtain such a lead over their competitors that we may look forward to the time when the advantages of industrial research will be recognized by all."

Among those who have made the advancement of the boundaries of human knowledge their life's work there still remain a few who regard science as a sort of private preserve for intellectual sportsmen and who draw an esoteric distinction between pure and applied science. With them research acquires sanctity in proportion as its results seem unlikely to be of any earthly use, while research, which has for its avowed object the satisfaction of some human need, is assumed to be tainted with commercialism and to involve a lower order of intellectual merit and achievement.

But the alarm clock has been heard even in laboratories devoted to so-called pure science and the splendid work of such great research laboratories as those of the General Electric Company and Eastman Kodak Company have amply demonstrated that the solution of industrial problems affords full scope for the highest scientific intellect and training. To again quote J. J. Carty, "In the last

analysis the distinction between pure scientific research and industrial scientific research is one of motive."

Fortunately also for the world the most self-centered investigator can make no addition to the sum of human knowledge which may not some day become a milestone of industrial progress.

The scientific study of the atmosphere to which Englishmen have so conspicuously contributed was for the most part carried on with no thought of making an industrial application of the results obtained. In 1785, Cavendish recorded the production of nitric acid on the passage of an electric spark through the air. Five hundred thousand horsepower are now employed in turning that discovery to practical account in the fixation of atmospheric nitrogen, in Norway alone. Recently, as it still seems, Dewar succeeded in liquefying air and in separating the oxygen and nitrogen by fractional distillation. Already this separation constitutes a fundamental factor in the methods for the production of synthetic ammonia, and the manufacture of the nitrogenous fertilizer known as cyanamid. Incidentally Dewar invented the thermos bottle as a container for liquid air.

Still more recently Ramsey demonstrated the existence in the atmosphere of five rare and unknown gases with unique properties. Of these argon is now manufactured in quantity in Canada and obtainable in liquid form in cylinders. To another, neon, we now confidently attribute the long mysterious phenomena of the aurora borealis. Tubes containing highly rarified neon may become as common to our descendants as candles to our ancestors. They glow with a rich, mellow golden light on the passage through them of an electrical discharge.

There are few men to whom the world stands in greater debt than to the French chemist, Pasteur. There is probably not a man in this room who is not under heavy obligation to him and except for his discoveries some of you would not be here at all. His demonstration of the germ theory of disease and the development of the serum and antitoxin treatments have saved more lives than the present awful war has cost all the belligerents combined. Such service is beyond estimate in monetary terms, but the direct financial value of Pasteur's discoveries was years ago appraised by Huxley as sufficient to cover the whole cost of the war indemnity paid by France to Germany in 1870.

In 1865 a fatal epidemic among the silk worms had ruined the silk growers of France. In June of that year Pasteur was called to the south of France to study the disease. In September he announced the method which proved successful for its control. Other studies saved the French wine industry from the destructive ravages of phyloxera, stamped out chicken cholera and anthrax, and for the first time put brewing and wine making on a scientific basis. Of him the English chemist, Sir Henry Roscoe, has said: "What was the secret power which enabled Pasteur to bring under the domain of scientific laws phenomena of disease which had so far baffled human endeavor? It simply consisted in the application to the elucidation of these problems of the exact methods of chemical and physical research."

To each one of you I commend the statement of Pasteur himself that "in the field of observation chance only favors those who are prepared."

Chance favored a man who was prepared when in 1828 the German chemist, Wohler, set aside to crystallize a solution of the inorganic compound cyanamid, only to find that the crystals which were deposited were those of the organic compound urea. The moment that observation was made the wall which in the minds of men had divided the organic from the inorganic world crumbled and disappeared and the science and industry of organic chemistry followed in logical and orderly development. In one department of the new science that boy of eighteen who later became Sir William Henry Perkin derived a dye stuff, mauve, from coal tar aniline and laid the foundation for an industry in which a capital of $750,000,000 is now employed.

Some of our greatest industries are concerned with the art of illumination and adequate illumination is in itself an important factor in determining the productive capacity of industrial plants. How would your balance sheet stand if your factory was lighted with tallow dips? We still give credit to King Alfred for shielding the candle by transparent strips of horn and thereby making the first lanthorn. But after the sun went down his palace was a gloomy place compared to the poorest workman's cottage of to-day.

The pulling of a chain, the pushing of a button now floods a room with brilliant light, solely because science during the past one hundred years has been applied to the problems of illumination. The gas works in every municipality, the great oil companies whose names are synonymous with

organized and profitable industry, the electric light plants, the carbide factories, the establishments throughout the world devoted to the manufacture of incandescent lamps, gas mantles, and countless other details of equipment are founded not on capital, not even on organization, but in the last analysis upon science. They owe their existence to the applied research of Murdock which developed gas from coal, of Lowe which led up to the gas producer, of Welsbach which discovered in the monazite sands of far-away Brazil the elements which so greatly raised the illuminating power of gas as to save the industry from what seemed to be the overwhelming competition of the incandescent lamp, of Wohler and Willson which gave us carbide and acetylene with oxyacetylene welding and the nitrogenous fertilizer cyanamid as by-products, of Davy which demonstrated the arc lamp, of Edison, Swan, Malignani, Howell and Coolidge, which initiated and developed that scientific marvel the incandescent lamp, and other unnumbered and perhaps forgotten workers who in their laboratories fabricated each his part of the structure of the industry.

An evening might be spent on a bare outline of what research has already accomplished for the steel industry. It promises to do still more. The microscopical structure of steel is a subject of daily study in more than two hundred laboratories in the United States alone. Many other evenings might be devoted to the exposition of the benefits of research in many other industries. And if the survey were complete no industry would be omitted.

Since, however, both your time and patience have their limits such a survey, however informing and convincing it might be, is impossible. But I venture to ask you to consider briefly with me some of the industrial developments which have resulted from research in a single field of chemistry with which I happen to be especially familiar. I refer to the chemistry of cellulose. It doesn't sound interesting, does it? Nothing in it to make a woman lay down her knitting, or a man his evening paper. And yet it is a subject of the most direct interest and importance to every man, woman and child.

Cellulose is the greatest structural material in the world. At least ten billion tons of it are produced by Nature every year. Without it the earth would be bare of vegetation, an arid waste without grass or trees or flowers. There would be no agriculture, no lumbering, or textile,

cordage, or paper industry, no food for animals and consequently no food for man.

Cellulose constitutes the structural basis of all vegetation. It is the material out of which plants build up the infinite variety of form and tissue which, more than anything else, perhaps, makes the world a pleasant place to live in and a storehouse of material adapted to human needs. The cell is the unit of plant structure and cellulose is the predominating constituent of the cell wall. Carefully purified cotton, as in the form of absorbent cotton, is practically pure cellulose in a particular structural form, but cellulose itself is colorless and transparent. It is remarkably strong and tough and singularly inert to the action of reagents. Dry wood is largely cellulose, spruce, for example, containing fifty-one per cent, and the vegetable fibres all consist of cellulose in more or less impure or modified form.

Obviously the textile industries, so far at least as the vegetable fibres like linen, cotton, ramie and so on, are concerned, are directly based upon the properties of cellulose. Any increase in our knowledge of these properties at once reacts upon these industries. When it was found, for example, that under regulated conditions cellulose would resist the action of chlorine, while the impurities associated with the cellulose were destroyed, the old grass bleach was soon superseded by the chlorine bleach. When it was discovered that an alkaline boil would dissolve most of these impurities, leaving the cellulose substantially unharmed, the rapid methods of the modern bleachery replaced the long exposure to sun and dew. In 1851 John Mercer noticed that the exposure of cellulose in the form of cotton yarn or cloth to a strong solution of caustic soda greatly strengthened the yarn or fabric and surprisingly increased its capacity for taking dyes. Unfortunately it shrank the fabric. Later to overcome this shrinkage, Thomas and Prevost subjected the yarn to heavy tension while still wet with caustic. The result went far beyond their expectations. Under the tension the twists and irregularities of the cotton fibre disappeared and the yarn assumed an amazing silky lustre. What was practically a new fibre was given to the world and it speedily revolutionized the manufacture of the finer sorts of cotton textiles.

Similarly, the paper industry has been revolutionized by three fundamental chemical facts, namely, that the impur-

ities associated with cellulose in wood can be dissolved under heat and pressure by caustic soda, by solutions of sulphites, and by solutions of sulphides. Upon the first is based the soda process for wood pulp, upon the second the sulphite process for wood cellulose, and upon the third the sulphate process for kraft pulp and paper.

In 1884 I was superintendent of the first sulphite pulp mill on the continent and we thought ourselves fortunate when our weekly output could be brought to fifty tons. Now a single New Hampshire mill makes 425 tons a day, and the total daily production in the United States and Canada is at least 7,000 tons with a present value of $840,000.

In 1819 Braconnot boiled up some cellulose in the form of an old shirt with sulphuric acid and found that the cellulose was converted to a sort of sugar, some of which he subsequently fermented into alcohol. He exhibited his results to the French Academy to the amazement of its members. A hundred years of industrial research has at last transformed that laboratory method into a commercially operative process, by which thousands of gallons of high grade ethyl alcohol are made from yellow pine sawdust. This is not wood alcohol but is identical in every particular with that commonly made from grain. The industrial importance of this achievement can hardly be overestimated. A cord of sawdust costing fifty cents yields ten gallons of ninety-five per cent alcohol, whereas a bushel of corn costing over eighty cents yields only two and one-fourth gallons, and a gallon of molasses worth at least fifteen cents gives only half a gallon of alcohol. By this process any vegetable waste which can be collected cheaply and in quantity becomes a raw material for alcohol and releases for their proper use as a food the corn and molasses now diverted to alcohol production. Incidentally it removes substantially all menace of a possible failure of the gasoline supply, since alcohol is equally available as a motor fuel.

In 1846 Schonbein in studying the effect of strong sulphuric acid upon cellulose in the form of paper observed that the paper was thereby converted to a sort of membrane, and in the following year Pomarede and Figuier began the manufacture of the now well-known parchment paper, which, because of its grease-proof property, is largely used for wrapping food products.

A later observation that cellulose is rendered gelatinous by a strong solution of zinc chloride led directly to the

manufacture of the vulcanized fibre so largely used as an insulating material and the production of innumerable articles in which lightness, strength and wearing quality are desirable. The vulcanized fibre is so dense and tough that it dulls the edge of cutting tools more quickly than sheet steel.

The observation that cellulose will dissolve in a solution of copper oxide and ammonia is the basis of the well-known Willesden method for rendering cloth and paper, water and insect proof. It led to the production of the first successful filament for incandescent lamps and is the essential feature in an important process for the manufacture of artificial silk.

Girard in studying cellulose noted that when the material is moistened with any dilute mineral acid and then dried, it is changed to a friable substance known as hydrocellulose. On this simple fact depend the processes for removing burrs from wool, cotton from mixed goods, and cotton and other fibres from recovered rubber.

Few discoveries have been more far-reaching in their influence than the observation by Schonbein in 1845 that cellulose on exposure to nitric acid was converted into a new and highly explosive product. For seventy years research has been focused on that observation. It led von Lenk and Abel to gun cotton; Viele, Nobel, Abel and Dewar to various forms of smokeless powder. It revolutionized warfare. It led Hyatt to celluloid, Goodwin to photographic films, du Chardonnet to artificial silk, and is the underlying fact on which is based the manufacture of patent leather, artificial leather, lacquers and a bewildering variety of other products which are everywhere in daily use. Hundreds of millions of feet of nitrocellulose film carry their message of instruction or amusement to hundreds of millions of people in the tens of thousands of moving picture theatres throughout the world each year.

In 1893 Cross, Bevan, and Beadle in London conducted a series of experiments which led to the discovery that when cellulose in the form of cotton or purified wood fibre is exposed to the simultaneous action of caustic soda and bisulphide of carbon, a new compound is formed known as cellulose xanthate or viscose, and constituting a golden yellow, plastic mass which is soluble in water. The compound is peculiar in that it may readily be decomposed by heat or acid with recovery of the cellulose in whatever form has been impressed upon the plastic mass, or the

solution. Chemists in every land were soon applying this compound to the most diverse industrial uses. It has been used for strengthening and coating paper, printing topical effects upon cotton cloth, for making water paints, as a substitute for glue, for making billiard balls, valve wheels and hundreds of small turned articles, and was in the year before the war the raw material for the production of twenty million pounds of artificial silk worth at a low estimate $35,000,000.

In our own laboratory the study of the action of acetic anhydride upon cellulose has led to the development of methods for the production of non-inflammable films for photographic and other purposes, waterproof artificial silk, a special insulation for the very fine wires used in electrical recording instruments, automobile goggles, lacquers, varnishes for aeroplanes, and other special products. The cellulose acetate which forms the basis of these products reproduces to a remarkable degree the physical properties of celluloid while possessing the important advantage of being non-inflammable.

When Abram S. Hewitt said that the Bessemer process for making steel adds $2,000,000,000 yearly to the world's wealth the figure was impressive but not wholly satisfying. It led us to wonder how much of that two billion came to us and where we put it. Perhaps if we deal in smaller figures we can keep track of our profits more easily. Not long ago a manufacturer was heard to say that he would give a million dollars if he could solve a certain technical problem which had arisen in his business. It was suggested that he take his problem to the Mellon Institute. He did so. The problem was there solved in eight hours and I believe he still has the million. We ourselves treasure a letter from a grateful client operating three large shoe factories which bears testimony to the fact that a certain research which we conducted for him has during the past two years saved him weekly more than the entire cost of the investigation. One hundred per cent a week is surely a satisfactory dividend, even where industrial research is concerned. It raises the suspicion, however, that possibly we should revise our system of charges.

A few of you may remember that in pre-prohibition days beer commonly became cloudy when placed on the ice. It was an objectionable tendency which the best skill of the brewers was unable to overcome. A little research by a clever chemist proved that the cloudiness resulted from

the deposition of albumenoids previously in solution. He remembered that pepsin digested albumen, added a trace of pepsin to the beer, and the thing was done. The beer remained bright at any temperature.

Not long ago a Jewish client brought to us a leather stain for which he was paying eighty-five cents a gallon. It proved to be water with a little gum tragacanth and still less aniline dye. We showed him how to make it at a cost of less than ten cents a gallon. He said he began to realize where the Gentiles get the money the Jews get from the Gentiles. In a plant near Boston using two tons a week of special steel, rolled very thin, their chemist was able in about two years to reduce the cost of this material from eighty to forty cents a pound, while at the same time standardizing and greatly improving the quality of the steel. Broken rails are more expensive than analyses and there are no dividends in broken trolley wires, defective castings, spotted or tendered piece goods or rejections in any line of manufacture. Competition is difficult when your wastes are your competitor's profit.

At no place in the world are the results of industrial research more strikingly evident than at Niagara Falls. The electrical energy derived from a small fraction of that stupendous flow produces, in its passage through electric furnaces and decomposing cells, aluminum, metallic sodium, carborundum, artificial graphite, chlorine, and caustic soda, peroxides, carbide, cyanamid, chlorates and alundum. The story of the electro-chemical development behind these products is an epic of applied science.

Most of the great corporations in the United States have awakened to the commercial value of research. They do not hesitate to spend great sums in the maintenance of superb laboratories and their scientific staff. They expect research to pay dividends and it does not disappoint them. One American corporation employs six hundred and fifty chemists.

Research on this great scale is of course wholly beyond the means of the average manufacturer, but it is also beyond his requirements. These are well served by such an agency as the Mellon Institute at Pittsburg or by group laboratories maintained by trade associations or by the higher grade of commercial laboratories which are almost institutional in character. The Royal Canadian Institute has recommended the establishment in Canada of an institution modeled on the Mellon Institute. If the millions needed for endow-

ment are forthcoming such a step could not fail to greatly stimulate and benefit Canadian Industry. The Canadian Manufacturers Association could hardly spend its revenue to greater advantage than in maintaining for the benefit of its membership a group laboratory along the lines so well laid down by the American Canners' Association, whose laboratory at Washington is devoted to the study of problems which vitally concern the prosperity of the industry as a whole. For manufacturers who desire to have their own specific problems solved there are available several highly organized and well equipped commercial laboratories which specialize in the application of chemistry to industry. The organization which I take pride in representing has come to Canada to serve Canadian manufacturers, to assist in the promotion of industrial research throughout the whole Dominion and to aid you in the survey and development of your amazing natural resources. To this service we bring an excellent equipment, the experience of thirty years and a compelling interest.

A very large proportion of industrial problems are problems in applied chemistry. Many of these so-called problems have already been solved somewhere. The present need of industry is not so urgent for new research and for new facts as for the immediate and proper utilization of facts already known and demonstrated.

Now, as Mark Twain said: "We all talk about the weather, but nothing is done." Let us not leave this room merely to talk some more about industrial research. If I have succeeded in convincing you that there is a place for research in your own business, or if you wish for concrete demonstration of its earning power in your own factory and on your own balance sheet, I offer you the opportunity to state your individual problems here and now. If you will do your part by filling out the blanks which your secretary will provide and put your problem definitely and plainly, my associates and I will esteem it a privilege to consider each one carefully and send you our best opinion as to the probability and means of its solution. There will be no expense to you except for such research as you may later and specifically authorize.

By way of suggestion let me point out a few of the more obvious fields of application for the research method.

There is first the control of quality of raw materials as in case of steel, alloys, bearing metals, lubricants, coal, paints, paper, cement, and practically everything else you buy.

Second, perhaps, is the problem of finding suitable substitutes for such supplies as are unobtainable or unduly high in price. For example there is the use of selenium in place of gold in the production of ruby glass, the substitution of tungsten points for platinum in spark plugs, of silica ware for platinum dishes for the concentration of sulphuric acid, of casein for glue, of chlorate of soda for chlorate of potash in dyeing, of zein, derived from corn, for the prohibited shellac for varnishing confectionery, of specification oils for oils whose value is largely in brand names, and of the specific indicated chemicals in place of high priced boiler compounds.

Of even greater importance is the scientific control of processes of production, control of formulas, temperatures, pressures, time and spacing, fineness of material, moisture content, and all the other factors which influence the quality and amount of your daily output. Correlative with such control are the studies having for their object the standardization of your product and the elimination of seconds and rejections.

Wastes can be minimized and often turned to profit by well-directed research. The waste liquor of the sulphite mills is now a source of alcohol and of adhesives. Barker waste is an excellent raw material for certain low grade papers. The Cottrell process of electrical precipitation effects the recovery of values of smelter fumes, cement dust, and many other chimney products. In some industries, as lumbering, the potential values in the wastes are greater than the realized values in the product.

The wholly abnormal conditions under which business everywhere is now conducted lend particular interest to another function of industrial research, namely, that of finding new outlets for present products and new products for existing plants. To take an extreme case, no one for example realizes better than the duPonts that the vast new plants which they have constructed for the manufacture of explosives to meet the requirements of the Allies will ultimately, and let us pray it may be soon, find their occupation gone. The sagacious officers of this corporation are therefore already turning their attention to utilization of their plant and special products in the constructive arts of peace. They have begun the manufacture of artificial leather, lacquers, celluloid, picric acid for use in dyeing, heavy chemicals and many individual dyes and intermediates.

In a less acute sense, but no less surely similar, problems confront manufacturers everywhere. They confront you. And their solution in anything but a hit-or-miss and half-way fashion involves intensive industrial research.

The steady spread of prohibition brings the problem home to every brewer and distiller on the continent. Must their great plants stand idle or be scrapped? Or can their special equipment be utilized in new and profitable ways which are within the law? Without attempting to solve the problem here and now I may suggest that cold storage, malt extracts, malted milk, clarified cider and grape juice and the production of concentrated fruit juices, by freezing methods, all merit careful consideration by the brewer, while the distiller may well turn his attention to industrial alcohol, solid alcohol, de-alcoholized wines, yeast, essential oils, ether and the manufacture of varnishes.

In its broader aspects the application of industrial research to the development of the natural resources of the Dominion and the promotion of the welfare and prosperity of its inhabitants holds out a prospect calculated to fire the dullest imagination. In Canada less than ten million people have come into an inheritance as rich in potentialities of wealth as that which has enabled one hundred millions in the United States to take first rank among the great producing nations of the world.

Furthermore, the development of the United States proceeded under the methods, knowledge and financial resources of the Nineteenth Century, whereas Canadians in the development of their inheritance have only to reach out and utilize the experience, methods and resources of the twentieth century. They have only to study the industrial history of the United States to learn what mistakes to avoid and what good to seize upon.

In industrial experience and scientific resource you Canadians stand to-day a century ahead of the tenmillion people who one hundred years ago were working out by crude and wasteful methods the industrial development of the United States.

The three factors which, as it seems to me, are essential for the industrial development of Canada are men, capital and research. Men may safely be trusted to follow the call of opportunity and probably never will that call sound more clearly than in the ears of those millions in Europe who after the nightmare of this war awake to find themselves heavy-burdened with its paralyzing costs.

The immigration of money is equally needful to your prosperity but not so easily assured as the immigration of men. There will be plenty of work at home for the pound sterling, the franc and the rouble, and I therefore urge you to devote yourselves to encouraging the immigration of dollars.

The control and expansion of the third factor which I have mentioned as essential lies wholly within your own hands. Moreover in proportion as you avail yourselves wisely and generally of the findings of industrial research so will the immigration of men and dollars follow the opportunities thus created. Well directed and protracted research is needed for collecting and correlating the widely scattered information regarding your resources, for demonstrating the value of the specific raw materials which you possess in such profuse abundance, for developing processes for their utilization, and finding new uses, and hence new markets, for the products made from them.

My own organization has, for example, already demonstrated that gasolene in commercial quantities may be extracted from the natural gas in certain fields in Alberta. We have shown that the waste flax straw now burned by your western farmers can be made to yield the highest grade of paper stock, for which there is at present an insistent and general demand. We have undertaken a very comprehensive research to demonstrate the feasibility of utilizing in various lines of industry the enormous tonnage of cereal straws now burned each year upon your prairies.

These things are a mere beginning. They hardly touch the fringe of opportunity. We have, however, entered definitely and seriously upon one phase of the great work in which through Lord Shaughnessy we have been privileged to assist. We are now organizing the Natural Resources Survey, which has for its initial purpose the collection, abstracting, classification and correlation of all available information regarding Canadian resources in such form that the essential facts regarding any of them may be almost instantly available to all those in position to use the information to advantage. Any adequate development of the plan involves covering a field so vast and the sifting of a mass of detail so immense that no single organization can expect to cope with it without the nationwide coöperation of institutions and individuals in position to assist. We shall call confidently upon your Association and upon many of you as individuals for this assistance.

While this work is begun at the instance of Lord Shaughnessy and will be carried forward under the auspices of the Canadian Pacific Railway, it is conducted for the benefit of no single corporation, but in the interest of the whole Dominion and of each of you individually as Canadians and manufacturers.

It is the misfortune of the United States that it has no Canadian Pacific Railway to initiate and support, especially in the South, a work of such magnitude and far-reaching benefit. Labor values and brain values constitute the most profitable exports for any country. The export of the brains themselves is an altogether different matter and the United States lost heavily on the day when Thomas Shaughnessy came to Canada.

In conclusion, let me point out that if the community is to receive the full benefits of industrial research the laboratory must be close to capital and closely in touch with industry. The results of research may long lie dormant and unappreciated unless they are placed effectively before those who are able to make use of them, and it is with the expectation of rendering efficient service along this line that Arthur D. Little, Limited, of Montreal, begins its work under a Dominion charter.

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RESEARCH IN CHEMISTRY.

Conducted by B. S. Hopkins.
University of Illinois, Urbana.

It will be the object of this department to present each month the very latest results of investigations in the pedagogy of chemistry, to bring to the teacher those new and progressive ideas which will enable him to keep abreast of the times. Suggestions and contributions should be sent to Dr. B. S. Hopkins, University of Illinois, Urbana, Ill.

THE PRESENT OPPORTUNITY IN CHEMISTRY.[1]

BY ROGER ADAMS,[2]

Assistant Professor of Organic Chemistry, University of Illinois.

A few years ago the public in this country scarcely knew what chemistry or what a chemist was. When this war started, however, a change suddenly took place. The chemist is now one of the most significant individuals in the majority of manufacturing plants, as well as of the most vital importance to the war. In England at Oxford University the study of chemistry used to be known popularly as the "Study of the Stinks," but now this science at that same university is certainly being shown its due respect.

I believe that the present opportunity of the chemist may best be pointed out to you by reviewing briefly the chemical development made in this country by the American chemists since the summer of 1914. It is needless to mention what a monopoly Germany had on chemicals before the war started, a monopoly not only in organic chemicals, but to a considerable extent in inorganic chemicals. As soon as the supply was cut off it was not a difficult matter for American manufacturers to increase the output of most of those substances which had already been manufactured, and develop the processes for other inorganic chemicals of a similar nature, so that within a year most of the inorganic substances purchasable before the war could be procured in this country. It was more difficult, however, to fill

[1]Address delivered before the High School Conference at the University of Illinois, November 23, 1917.

[2]Dr. Adams has taken a prominent part in the effort to meet the American demand for organic chemicals whose supply has been cut off by the war. He has entire charge of the commercial manufacture of organic chemicals at the University of Illinois and is a member of a committee appointed by the American Chemical Society to arrange for cooperation among the large institutions in supplying organic compounds to educational and technical laboratories. He is also a member of a committee authorized by the National Council of Defense to consider problems in connection with organic chemicals and synthetic drugs.

the increased demand for sulphuric and nitric acids which were most urgently needed in enormous amounts for the manufacture of explosives. Few people realize the large quantities of sulphuric acid needed in a country like the United States; in fact it has often been said that the civilization of a nation can be told by its output of this acid. In spite of Germany's prestige in chemistry, it was not more than ten years ago that the Badische Anilin & Soda Fabrik paid a very large sum of money to American manufacturers to find out the best apparatus for the making of sulphuric acid. The large increase in the production of nitric acid involved more complications, for the salt peter necessary had to be imported from Chile. Fortunately, this importation could be increased in a comparatively short time until the output of nitric acid was large enough to supply the demand. With the entrance of the United States into the war, the Government considered the problem of nitric acid much more seriously because it was necessary to rely entirely upon Chile for the raw materials needed for producing this acid. If Germany had not solved the problem of synthesizing nitric acid without the use of Chile salt peter, she could not have continued the war for a year with the supply of materials on hand in that country in 1914. Last April a committee of prominent American chemists was appointed to investigate the situation in the United States and to make recommendations to Congress. These recommendations were passed, and $35,000,000 was appropriated for purchasing a reserve supply of sodium nitrate, while $20,000,000 was set aside for the development of the general problems of fixation of nitrogen from the air. Of these fixation methods, there are three which have been used commercially in the European countries up to the present time: the arc process of combining directly nitrogen and oxygen to form the oxides of nitrogen; the cyanamide process consisting of a direct combination of calcium carbide and nitrogen to form calcium cyanamide; the Haber process, a direct combination of nitrogen and hydrogen in the presence of a catalyzer to form ammonia. By the first process, nitrates can be formed by absorbing the oxides of nitrogen in alkali. In the second, the calcium cyanamide is treated with steam to yield ammonia, which can then be oxidized quantitatively to nitric acid in the presence of air and a catalytic agent. In the same way the ammonia obtained in the Haber process may be converted to nitric acid. The first method is practicable only

where a large amount of water power is available, consequently the latter two are those now being used in Germany. The General Chemical Company of this country nearly five years ago foresaw the necessity of synthesizing nitric acid from the air, and set their chemical experts to work on the problem. A process was developed which is now ready to be put into commercial operation, a process far superior to any that has been used in Germany or other countries. It consists in making ammonia, then oxidizing it to the acid. Although similar to the Haber process in that ammonia is produced by the direct combination of nitrogen and hydrogen in the presence of a catalyzer, it has the distinct advantages of using much lower temperatures, obtaining double the yields, and involving simpler mechanical apparatus. Of the $20,000,000 appropriated, the committee recommended that $3,500,000 be devoted to a plant to be erected in Sheffield, Ala., capable of producing 60,000 pounds of ammonia per day by the General Chemical Company's process and of converting this ammonia to nitric acid. Much smaller sums were set aside for the further study of other methods, excluding the arc method, which seemed impracticable at present. The most promising of these is that developed by Professor Bucher of Brown University during the last ten years, consisting of the reaction of sodium carbonate, coal, and nitrogen in the presence of iron as a catalyzer to form sodium cyanide, which by boiling with caustic soda gives ammonia and sodium formate. The ammonia can then be oxidized to nitric acid. The prospects are bright, therefore, that within a year the United States will be independent of foreign lands for their nitric acid.

Of the other inorganic chemicals, the lack of potassium salts was most seriously felt. Formerly, these had been imported almost exclusively from the Stassfurt beds of Germany, so that to supply the needs of the United States it became necessary to seek other sources. The kelp industry developed to an enormous extent, especially along the California coast; the extraction of potassium from alunite and other potassium-containing silicates met with more or less success; the extraction from beet sugar residues became a large business; the extraction from various natural brines and salts increased remarkably. Searles Lake in California alone is said to contain ten million tons of potassium salts, and the process of separation from the other salts is already a practical proposition. Finally, many plants

for the extraction of potassium from wood ashes have been started, and in the Middle Western States huge amounts of corn cobs are burned daily for the large percentage of potassium that the ashes contain. To show the marked increase in the potassium industry, a few figures may be given. In 1915, the output of the various potassium compounds corresponded to a thousand tons of potassium oxide; in 1916 to ten thousand tons of potassium oxide; and the indications are that in 1917 the output will correspond to between fifteen thousand and twenty thousand tons. About forty per cent has come from the natural salts and brines, forty per cent from kelp, and twenty per cent from the other sources mentioned above. Thus the potassium difficulty is being satisfactorily solved.

Although much smaller in volume, the lack of an organic chemical industry was much more keenly felt by the general public. When a man's new black overcoat or a lady's black spring hat turned green in the course of a few weeks, that particular person began to realize that something should be done in regard to the dyestuff industry. In the same way, when thousands of persons could not purchase the medicinals they formerly used, these individuals began to feel that this country needed something more than a chain of drug stores. The organic chemicals may be divided into four groups, explosives, dyes, drugs and photographical developers, and fancy organic chemicals.

It is hardly necessary to mention the explosive industry. It was a strong one in this country before the war, and a comparison of the exports in 1914 with those of 1917 will serve to make one understand how rapidly it has expanded. In 1914, $6,000,000 worth were exported; in 1917, the figure will reach $1,240,000,000.

As for the dyes, the seeming slowness in their manufacture during the first year of the war may be excused when it is realized that the most fundamental substances, as well as the intermediate compounds, had to be manufactured before the finished products could be made. Germany had such a complete monopoly in this line of chemicals that the commonest substances were not produced in this country. When it became necessary, however, to develop this industry, which consisted before the war of five American concerns of comparatively small size that did some manufacturing but were for the most part importers of foreign dyestuffs, the manufacturers came to the front.

At present, there are 150 firms producing either intermediate products or finished dyes, and of these at least fifteen are very large corporations. Already, about eighty per cent of all the dyestuffs which were imported before the war are now being manufactured in this country, and it is probable that half of the remaining twenty per cent will be on the market within the next year. The final ten per cent are very complex in nature, difficult to prepare, and needed only in small amounts. When it is brought to one's attention that for some of the common cotton dyes it requires more than twenty distinct processes in order to get the finished product, it is remarkable that the development has been as rapid as it has. It is true that high prices still persist, so that only the more expensive goods contain the better dyes, but this is simply because the manufacturer has invested large amounts of money, and as long as possible intends to make a big profit. Moreover, he prefers to work out at this time the preparation of new dyestuffs rather than spend his energy in developing to a greater extent the ones which he has already produced successfully in a commercial way. In 1913, $350,000 worth of dyes were made in this country; in 1917, $12,000,000 worth, and of this $12,000,000 worth, a very appreciable proportion has been exported. Last July alone, $500,000 worth were shipped abroad, chiefly to Argentine, Brazil, Japan, and British India.

One often hears it asked why American manufacturers did not enter this field before the war. The reply has been that it was due to the fact that we did not have good chemists in this country. That is a great mistake. The dye industry was not taken up for two reasons. First, no really large concern cared to go into this work, and smaller concerns were unable to compete with the German industrial methods. One specific example may be cited. About six or eight years ago, a concern in the East built a $200,000 plant for the production of aniline. At that time, aniline sold for twelve cents a pound and these particular manufacturers were able to produce it at 11 cents. Not long after their product was on the market, the imported material suddenly dropped to between nine cents and ten cents, and upon investigation it was shown that the German manufacturers were selling below cost. This was continued for nearly a year and a half until it was necessary for the American dealers to drop the business. About three months after that date the price of the imported material rose to thirteen cents a pound.

The question as to why a larger manufacturer did not take up the work may be easily answered. Although the business was extremely important, it was not large enough to attract the American investor, because the labor and experimentation costs were great, and the returns would have been comparatively small, particularly on account of the keen competition which was sure to come from Germany. The following illustration will serve to bring out this point. All of the various color industries in Germany together manufactured over twelve hundred products and controlled probably eighty per cent of the world's markets. They paid in 1913 dividends to the amount of $13,000,000. In the same year the Ford Motor Car Company, which produced only one article, earned four times the amount of all these German color industries together, and paid at the same time three times the wages. Many more instances of this same kind might be given. The dye industry in this country is now here to stay, however. Not long ago I was told by the head of a big factory that they were producing many of the chemicals which were needed in very large amounts at a cost thirty per cent to forty per cent below what these substances sold for before the war, in spite of the fact that their raw materials were much more expensive. With a reasonable protection by the United States Government, the indications are that the American dye industry in the next decade will become second to none in the world.

The photographic developers have gradually been manufactured at the same time as the dyestuffs, so I will pass over this interesting group of substances and speak briefly of the drugs. Even before the summer of 1914 this country produced and exported large amounts of natural medicinals, substances extracted from plants, as quinine, strychnine, etc. But comparatively few synthetic drugs, those made up in the laboratory from simple organic substances, were produced in this country. At the present time, however, practically all the common ones are made and even exported in large quantities. The synthetic drug industry is a much newer one than the dyestuff, and many of the important drugs are still under the patent laws, and these patents are held chiefly by alien enemies. Since some of these substances are of extreme importance, the Government, a short time ago, passed a bill which would allow a reliable American manufacturer to obtain a license from the Federal Trade Commission to produce these substances provided

he pay into the United States Treasury five per cent of the gross proceeds from his sales. This arrangement is to proceed until a year after the war is completed, six months from which time the patentee must sue the American dealer for his royalty. A court is then to decide whether the five per cent is large enough or too large, and the exact amount to be paid to the patentee will be settled. This bill, however, does not suit the American concerns, and a number of the larger ones have been unwilling to take up the manufacture of these patented drugs under such conditions. The American Government is willing to license more than one concern for the manufacture of these drugs, and therefore there will be competition, not only at the present time, but even keener competition with the German producers after the war. Although the bill has been passed for five or six weeks, comparatively few applications for licenses have been made, and many of these have come from concerns controlled by German capital. A few American manufacturers will no doubt undertake the production of certain of these patented drugs for which the demand is extremely large and where the indications are that the necessary investments will be paid for and big profits made before the war is over. In this group may be mentioned especially salvarsan, needed so extensively in the army, and novocaine, a local anaesthetic of the greatest value. There were some hundred or more other drugs manufactured almost exclusively in Germany and sold in this country before the war which had only a very specific use and consequently for the most part only small sales. Many of these are still under the patent laws. The remainder are not, but it will be a long time before American concerns will undertake the synthesis of these substances. The demand is small, the manufacture difficult, and in most cases nearly as good substitutes of much simpler nature are on the market. The drug industry in this country at present, although not as satisfactory as that of the dyes, is being rapidly developed, and it will not be long before the United States will hold its own in this branch of chemistry.

The last class of organic substances is the fancy organic chemical reagents. These include not only the materials badly needed for scientific research, but also those almost indispensable for analytical work, food testing, etc., as dimethyl glyoxime for the quantitative determination of nickel, cupferron for the separation of iron and copper, phenyl hydrazine for sugar

separations, and many others. Considerable quantities of these compounds were on hand in this country when the war broke out, held chiefly by university laboratories and distributing concerns. By careful conservation on the part of the universities and greatly advanced prices on the part of the distributing houses, a serious lack of these reagents was not felt until this last year. The manufacturers have not attempted, and will not at present attempt, to produce these compounds, on account of the comparatively small demand, on account of the skilled chemists that it needs for this work, and on account of the very small profits involved. The University of Illinois undertook the work of preparing many of these substances which were needed most. Since the 1st of June a number of graduate students have been employed in this laboratory and have made up to the present time over one hundred different compounds which had not been manufactured in this country before and which were badly needed by laboratories all over the country. In this work special attention has been paid to developing the processes from the laboratory scale of 25 or 50 grams to a scale of 1 or 2 pounds, and thus it has been possible to give the men a training not to be obtained in any other way in a university, a training of the kind most needed now in the chemical industry. At the same time, valuable service has been rendered to scientific, technical, and Government laboratories throughout the country. Moreover, the students have been paid enough so that their living expenses would be covered. Amounts of these reagents varying from a few grams of certain ones to nearly a hundred pounds of others have been made and sent away, and the business already has amounted to between $7,000 and $8,000, which is large if it be considered that not a single piece of apparatus has been used which was not formerly at hand, and not a single man doing the work has had any training outside the university. At the present time the cooperation of other large universities is being sought so that more ground may be covered. It is hoped to form an organization for the manufacture of this class of substances which will continue not only until the war ends, but until such a time as a large American manufacturer will undertake the work, not for profit, but to help the United States become independent of foreign laboratories.

One other phase of chemistry should not be overlooked at the present time, the chemistry of gas warfare. This can hardly be called an industry unless it is determined by the amount of

money expended for its development. England is spending $125,000 a day simply for its study, and that sum does not include the cost of manufacture of the material actually used in the fighting. In February, 1915, the first attacks were made with chlorine and bromine. Four days after that attack, the English had provided one million troops in France with protective masks. Since that time, the intensive study of poisonous gases and liquids and the protection therefrom has been the serious problem of the leading chemists in the various warring nations. Last spring a large per cent of all the shells fired on the Western front were liquid shells, and that number is increasing continually. The use of gases has been given up to a considerable extent as they are too volatile and soon blown away. What is sought for now especially are liquids, boiling between 100° and 200°, tear-producing and poisonous. These will often remain on the ground for days and prevent the soldiers from remaining there except when wearing their masks. The first attack at Verdun was made with a new liquid which was not absorbed by French gas masks, and it is reported that the original attack on the Italian front a few weeks ago was started with a liquid which had not hitherto been used. The extreme importance of this warfare can immediately be seen, for if it were possible to obtain a poisonous liquid or gas not absorbed by the enemies' masks, and which could be produced and used in large amounts, the chances of breaking through a line not supported by many reserves would be great. There are, at Washington, at the present time, between two and three hundred chemists working continually on the development of different phases of this warfare, from the offensive side as well as the defensive side. An interesting point in connection with this work is the great secrecy needed, since the secret service of the various nations is most active and effective. Not many months ago, it was reported that the Germans used a colorless, odorless liquid or gas which when breathed gradually poisoned the soldiers, caused blindness in the course of a few days, and subsequent death. This report was true, but before the material was used on the Western front the English Secret Service had found out what it was, how much the Germans were capable of manufacturing, had obtained blue prints of the mechanical apparatus, and these were in England long before an attack was made with it. This allowed time for developing sufficient protection for the men.

It can be seen, therefore, that the present opportunity in chemistry is great, and the advancement already made shows that the American chemists are not behind those of other nations. The demand for men with a chemical training is enormous at the present time, not only for those who have had a training in research, but also those with simply a Bachelor's Degree. One concern wrote to me just the other day, stating that they had sixteen positions to be filled, and other similar instances are arising from time to time. I, personally, feel sure that the demand is not a temporary one but permanent, for the chemical industry in the United States is now on its feet. Whereas the salaries offered beginning chemists five years ago varied from \$50 to \$75 or \$80 a month for a man who had had four years' undergraduate training, and \$75 to \$100 a month for men with considerable graduate training or even a Doctor's Degree, at the present time a concern would not consider offering less than \$1,200 to \$1,500 for a man who had had a college training in a good university, or less than \$1,500 for a man with some graduate training, while to men with a Ph. D. the offers seldom fall below \$2,000 and often are greater than that. This last June, one of our students who received his Doctor's Degree, a man who was not more than an average student, received a position at \$2,300, and this fall was raised to \$2,700, a salary which puts to shame the majority of the assistant professors' salaries in this and other universities.

It would be possible to consider almost indefinitely the various interesting phases of the chemical field, but I shall simply mention that large numbers of chemists are also needed in the oil industry, for water and food testing, for the development of new and more efficient antiseptics and drugs, for the study of new alloys for all kinds of engines, in fact for innumerable fields of the greatest importance.

Thus a few of the accomplishments of the American chemists and something of what they are attempting to accomplish have been put before you. A relatively large number of these have doubtless begun their chemistry in the high schools, and only when one is reminded of this is the importance of the work of the high school teacher realized. A student never loses his first impression of a subject, and it is possible thus to make or break a man for any field in the first few months of training. The new student must have his interest in the subject aroused, he must be made to feel the importance of it, and he must be able to see that chemistry is a connected field and not a mass of isolated facts.

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The Field for Chemists[1]

By Wilder D. Bancroft

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Chemistry is the science which deals with all properties and all changes of matter that depend on the nature of the substances concerned. According to this definition,[2] which is broader than the usual one, chemistry is the fundamental and dominant science, which may account for its being the most fascinating one. Chemistry, as thus defined, may be interpreted to include all of what is known as physics except the law of gravitation, the laws of motion, and a few other abstract formulations. Everything else that gives life and interest to physics is chemistry by definition. Our friends, the physicists, look upon physics as the fundamental science because physics was a well-developed subject before there was any scientific chemistry worth mentioning. This method of reasoning is natural but not necessarily sound. As children we were told that great oaks from little acorns grow. This is true but not the whole truth. If we have only the acorn, it is, of course, the important thing; but, later, one sees that the acorn is merely an interesting subdivision or product of the oak.

Engineering is largely applied chemistry. If it were not for the specific properties of iron, copper, concrete, brick, and all the other materials of engineering, there would be no such subject as engineering, which, speaking broadly, is the art of making the structural properties of matter available to man.

In the biology of the present and the future, we are interested in the chemical changes in the living organisms due to heredity and environment. Growth is a chemical change and the internal and external structures are the result of a series of chemical changes. After the first stages of identification, enumeration, and classification have been passed, the interests of the biologists are largely chemical, and the closer the contact with chemistry the better the results. This has been shown very clearly in the brilliant work of Loeb and his pupils; and Clowes has made it clear that Loeb's results as to the antagonistic action of sodium and calcium salts on protoplasm can be duplicated in a remarkable way with oil and water emulsions.

In curative medicine we are dealing largely with the action of drugs. In preventive medicine we are dealing largely with inoculations, diet, exercise, and fresh air. In the first case we are checking and eliminating an abnormal chemical process, sickness, by the action of one set of chemicals on the system. In

[1] Prepared January 1921. Received November 7, 1921.
[2] *Science*, [2] **27** (1908), 979.

the second case we are preventing the occurrence of a disturbing chemical process, sickness, by the action of another set of chemicals on the system. Owing to the difficulties involved and to the number of variables concerned, our knowledge of the chemistry of medicine is not yet what it should be; but it is clear that real progress will be made just in so far as we study physiology and medicine as subdivisions of chemistry.

Geology is the study of the chemistry of the earth, and agriculture is clearly a subdivision of chemistry. The fertility of the soil and the growing of crops are chemical problems in spite of the fact that they have been studied empirically for centuries.

Professor Stieglitz of the University of Chicago has said that chemistry makes possible the scientific control of such widely divergent industries as agriculture and steel manufacturing.

It governs the transformation of the salts, minerals, and humus of our fields and the components of the air into corn, wheat, cotton, and the innumerable other products of the soil; it governs no less the transformation of crude ores into steel and alloys which may be given practically any conceivable quality of hardness, elasticity, toughness, or strength. Exactly the same thing may be said of the hundreds of national activities that lie between the two extremes of agriculture and steel manufacture. Moreover, the domain of the science of the transformation of matter includes even life itself as its loftiest phase. From our birth to our return to dust, the laws of chemistry are the controlling laws of life, health, disease, and death. The ever clearer recognition of this relation is the strongest force that is raising medicine from the uncertain realm of an art to the safer sphere of an exact science. To many scientific minds it has even become evident that those most wonderful facts of life, heredity and character, must find their final explanation in the chemical composition of the components of life-producing, germinal protoplasm; mere form and shape are no longer supreme, but are relegated to their proper place as the housing only of the living matter which functions chemically.

Research Problems in Pure Chemistry

The student who wishes to take up research work either in pure or applied chemistry can find innumerable problems in every field and of any degree of complexity and importance, from work that can be done by an undergraduate to work that no one sees how to do at present. No matter where we turn, we find that we have only touched the fringe of the subject. A few illustrations may be helpful. To those in the Chemical Warfare Service, the war brought out clearly the meagerness of our knowledge even in regard to the simplest organic compounds. It would be quite impossible to-day to write a satisfactory monograph showing the reversible equilibria between the compounds of carbon, hydrogen, and oxygen, even if we limited ourselves to compounds containing not over three atoms of carbon to the molecule. If we went as high as compounds containing six atoms of carbon, our monograph would consist chiefly of gaps.

The whole problem of chemical affinity as applied to organic compounds is in a very rudimentary state, and while we are accumulating data in regard to free energy, our progress is very

slow. The Periodic Law is still very much of a mystery to us and we do not know why a consideration of the atomic numbers removes some of our troubles. We know a good many facts about catalysis in general and contact catalysis in particular; but we have no adequate theory on the subject, though the poisoning of catalytic agents is not the mystery it once was. While several books and innumerable articles have been written on the subject of indicators in quantitative analysis, nobody has collected the facts that the analyst really wants.

When it comes to color, we speak learnedly of chromophoric groups; but we do not know why anhydrous copper sulfate is colorless, why a solution of copper sulfate in glycerol is green, or why the absorption spectrum of a concentrated copper bromide solution is very closely the sum of the absorption spectra of a copper sulfate solution and liquid bromine.

The organic chemist finds an enormous amount of scientific work still to be done in connection with the synthesis of dyes. The whole field of chemotherapy is just opening up. The problem of plant synthesis has scarcely been touched. We can make in the laboratory many of the substances which the plant makes. Some of them, such as alizarin and indigo, we can make more cheaply than the plant can and of a higher degree of purity; but we cannot make any of them in the way the plant does. The plant does not use reverse coolers or sealed tubes; it does not boil with sulfuric acid or fuse with caustic potash; it has not metallic sodium and chlorine gas for reagents. The reagents on which the plant can draw are air, water, and a few mineral salts. With these and under the influence of heat, light, difference of electrical potential, and enzymes, the living protoplasm manufactures its product.

While the general theory of photochemistry is quite simple—that light tends to eliminate the substances which absorb it—our knowledge of the chemistry involved is so limited that we cannot actually treat photochemistry scientifically. We have made no progress in the direct utilization of the sun's rays and, while we think we know something about the conditions for chemiluminescence, we cannot produce cold light even though the firefly has shown us that it can be done.

Technical Problems

On the more strictly technical side, the problems are so numerous that it will only be possible to indicate a few. If our present civilization is to pull through, the scientific man must speed up production of crops and goods so that the masses of the people can live decently. While everybody will have to help in this, the bulk of the strain will come on the chemist and he must be prepared to meet it. We appreciate already the importance of nitrogen fixation and of getting potash from feldspar. The whole question of the better utilization of our petroleum resources is a vital one. Fortunately this has been realized by the oil producers and consumers, and Dr. Van H. Manning, formerly Director of the United States Bureau of Mines, has been appointed Director of Research of the American Petro-

leum Institute, which means that this work will be pushed as rapidly as possible. The American Institute of Baking is trying to improve the quality and keeping power of bread. The use of flotation processes has made it possible to work ore deposits which otherwise could not be handled profitably. The statement has been made that sixty million tons of ore are treated annually by these processes in the United States. While this is very gratifying, the development has been largely empirical so far, and we apparently have no realization as yet of the possible future applications of these processes.

When we consider ceramics, rubber and other plastics, paints, varnishes, leather, dyeing and printing, cellulose, cellulose nitrates and acetates, photography, etc., all subjects involving a large amount of colloid chemistry, we find that the industries concerned have a vast amount of empirical information as to what happens and know practically nothing about why it happens. The silicate industries are avowedly empirical and so is the dyeing industry. The rubber industry knows practically nothing about the theory of vulcanization, to take a single illustration. So far as can be learned the people in the cellulose nitrate industry do not even know how many cellulose nitrates there are or what their real properties are. The photographic industry has only empirical knowledge in regard to emulsions and has no adequate theory in regard to photographic developers. Nearly all of the tanneries in the country are run on an empirical basis. While many firms in these various industries have made a great deal of money, all our experience is that every increase in the scientific knowledge of a subject is followed sooner or later by an improvement in the technical processes, and it is certain that the industries in question will prove no exception in spite of the fact that each industry, which is run on an empirical basis, invariably believes that its case is exceptional. The recent work of Dr. Wilson on quebracho and gambier and on the analysis of tannin brings out clearly some of the important things which had been overlooked by the leather industry. All these industries will eventually be put on a sound scientific basis and this work will have to be done by chemists.

Present Position of the Chemist

The general position of the chemist is better than it has ever been before. The war has brought to the public mind an appreciation of the importance of chemistry. Some of the universities have already put their professors of chemistry on a special basis and the others will have to follow suit if they hope to fill vacancies with good men. In most universities the pay of the younger members of the staffs has, very properly, increased more relatively than that of the full professors. There used to be very few research fellowships for men who had received their doctor's degree, but now we have the National Research Council Fellowships in Physics and Chemistry which are open only to applicants who have received the doctor's degree or its equivalent. Some of the universities have similar research fellowships. The du Pont Company is giving a number of unrestricted fellowships

open to graduate students, and other companies are doing likewise though not to such an extent.

In the industries the Research Laboratory of the General Electric Company is the best known; but there are a number of other large ones, those of the Western Electric Company, the du Pont Company, the Eastman Kodak Company, the National Carbon Company, The Barrett Company, the National Aniline Company, the Goodrich Company, the Goodyear Company, the Brown Company, and the one of the General Electric Company at Nela Park being conspicuous instances. In addition very many companies are running smaller research laboratories. It looks also as though in the plants the ratio of chemists to engineers was going to increase considerably. Of course, the almost insane demand for chemists that prevailed at the end of the war has ceased and most companies are now discharging chemists as well as other technical men. When the present industrial depression is over, things will adjust themselves and we shall get on a normal basis. It looks now as though the next thirty years would be the period of the chemist just as the previous thirty years were the period of the engineer.

America's Synthetic Chemical and Medicinal Industry— "*The Way of Progress*"

The Debate in the United States Senate
on the
Bursum Amendment to the Tariff Bill
H.R. 7456

Reprinted from the Congressional Record
August 17 and 18, 1922

Synthetic Organic Chemical Manufacturers Association
OF THE UNITED STATES
ONE MADISON AVENUE
NEW YORK, N. Y.

* * * "I voted for the embargo when it was proposed by the Democratic Party. I voted for it during the war. I continued to vote for it when it was continued when the Democratic Party had not yet gone out of power. I voted for it for the sole reason that I wished the country to be independent in the matter of organic chemistry. No matter what it may cost, it is something that is worth any price they choose to pay to make the country independent in that direction." * * *

—Senator Lodge.

* * * "I believe that in organic chemistry lies the solution of the secrets of the past and of the future. I believe that its establishment and maintenance in this country, even under an embargo, mean the happiness, the progress, and the security of 100,000,000 people. No rate of duty will frighten me and no embargo will frighten me." * * *

—Senator Wadsworth.

* * * "In considering this amendment we must bear in mind how necessary it is to establish and maintain a strong chemical industry in America, how essential this industry is for our welfare, our national defense, and, in a more important way, our public health." * * *
* * * "Why can not American chemists discover remedies for cancer and leprosy and that most fatal of all diseases—tuberculosis? Great efforts to that end have already been made by American chemists. Let us encourage them in every possible way." * * *

—Senator Ransdell.

* * * "I feel that interest in this very great and important industry. It has done so much within the short time it has been in existence since the beginning of the war, produced so

much of wealth for the United States, given employment to so many thousand workmen, skilled and unskilled, in the United States, it seems to me that as American citizens, with pride in our industrial development, we should maintain and encourage it in the highest possible degree."

—Senator Sterling.

* * * "There is a higher motive in my desire to have the protective duties in this amendment adopted, and that is the question of national defense. When we realize that it was due to the genius of the German chemists, and the advance in the science by the German industries, that enabled Germany to get almost to the channel ports; when we realize that the next war will be fought with chemicals, I think it is our patriotic duty to give this industry the highest protection that can be imposed." * * *

—Senator Frelinghuysen.

* * * "However, Mr. President, here is an amendment which I think concerns a so-called key industry; I think it is an industry which is essential for the welfare of the country; and I think it had the moral promise of support by this Government;" * * *

—Senator Jones, New Mexico.

* * * "It has not been long since we sent to the other side of the seas 2,000,000 Americans to suppress the ambition of Germany to set up an autocracy of the world. American blood was shed on foreign soil to save the world, and if we are to allow this industry now to perish, that shedding of blood will have been in vain. We will have set aside what was obtained through the great World War. We will have put America at the mercy of the Germans again." * * *

—Senator Bursum.

The Bursum Amendment:

The ASSISTANT SECRETARY. It is proposed to amend paragraph 25, coal-tar products, lines 17 and 18, on page 10, by striking out the words "50 per cent ad valorem and 7 cents per pound" and inserting in lieu thereof the following:

Seventy-five per cent ad valorem based upon American selling price (as defined in division (f) of section 402, Title IV) of any similar competitive article manufactured or produced in the United States, and 10½ cents per pound. If there be no similar competitive article manufactured or produced in the United States, then the ad valorem rate shall be based upon the foreign value or the export value, whichever is the higher, as defined in paragraphs (a), (b), and (c) of section 402, Title IV. For the purposes of this paragraph any coal tar products provided for in this act shall be considered similar to or competitive with any imported coal-tar product which accomplishes results substantially equal to those accomplished by the domestic product when used in substantially the same manner: *Provided,* That no duty imposed under this paragraph shall be increased under the provisions of section 315.

* * * * * *

The ASSISTANT SECRETARY. It is proposed to amend paragraph 26, on page 11, line 21, by inserting after the figures "1546" the words **"all synthetic organic medicinals and chemicals not specially provided for."**

Also, amend paragraph 26, line 6, page 12, by striking out in line 6, the words "60 per centum ad valorem and 7 cents per pound" and substituting in lieu thereof the following:

Ninety per cent ad valorem based upon American selling price (as defined in division (f) of section 402, Title IV) of any similar competitive article manufactured or produced in the United States and 10½ cents per pound. If there be no similar competitive article manufactured or produced in the United States, then the ad valorem rate shall be based upon the foreign value or the export value, whichever is the higher, as defined in paragraphs (a), (b), and (c) of section 402, Title IV.

Also, amend lines 7, 14, and 17, on page 12, by striking out the figure "7" and inserting in lieu thereof the figures "10½."

Also, on page 15, line 16, after the word "impress," add the following:

For the purposes of this paragraph, any coal-tar product provided for, and all synthetic organic medicinals and chemicals not specially provided for, in this act shall be considered similar to or competitive with any imported coal-tar product or any synthetic organic medicinal or chemical not specially provided for, which accomplishes results substantially equal to those accomplished by the domestic product when used in substantially the same manner: *Provided,* That no duty imposed under this paragraph shall be increased under the provisions of section 315.

The Debate:

Mr. BURSUM. Mr. President, the serious question confronting the country at this time, which prompted the introduction of this amendment, is whether the dye industry of this country shall be permitted to live, whether it shall be preserved, or whether we will permit it to go on the rocks, and depend upon Germany, as we did prior to the war, for our supply of dyes.

The duties which are provided for under the bill are wholly inadequate. It would be impossible, upon the basis of the cost of production in this country, for the dye industry to continue business with those duties.

I have taken the first four dyes on a list of about 100, comparing the reparation prices of the German dyes with the cost in this country, and I find as follows:

Auramines: German cost, 50 cents. The duty accorded in the present bill is 60 per cent plus 7 cents, which would amount to 37 cents. Total landed cost of German dyes laid down in this country, 87 cents. American price, $1.50.

Naphthol yellow S: German cost, including duty, 32.7 cents; American cost, $1.75.

Chrysophenine G: German cost, together with duty, 29.4 cents; American cost, 90 cents.

Metanil yellow: Laid-down German cost, 44.8 cents; American cost, 90 cents.

Sulphur yellows, sulphur greens, and sulphur violets: Laid-down German cost, together with duty, 18⅔ cents; American cost, $1.50.

Alizarin 20 per cent paste: Laid-down German cost, 9.44 cents; American cost, 55 cents.

Indigo 20 per cent paste: Laid-down German cost, 16.6 cents; American price, 25 cents.

Sulphur blacks: Laid-down German cost, 18.2 cents, as compared with 30 cents.

Chrome blacks and diamond blacks: Laid-down German cost, 31 cents, as compared with 80 cents.

It is obvious that under the rates which have been adopted here, for the dye industry to continue will be simply impossible. That fact is recognized by the Senate. It was for that reason, I take it, that the special provision was made authorizing the President, under section 315, to increase or decrease duties to the extent of 50 per cent and adopt the American valuation upon coal-tar products.

The amendment which I have introduced does specifically what the Senate authorized the President to do in the way of increase. The reason for this is manifest. It would be impossible for the Tariff Commission to investigate and report a schedule of duties upon the dyestuffs of this country within a shorter period than six months or possibly a year. The subject is a very intricate one. There are thousands of these dyes. To ascertain the costs abroad and at home is no small affair. It involves a great deal of work, and work by experts; and in the meantime the dye industry would be dependent upon the inadequate duties which have been provided for under the pending bill. For that reason it is eminently necessary that protection of some kind which will carry the industry over until the rates can be made shall be provided for.

Mr. President, we have had an embargo since 1918. It seems to me that it is entirely fair and reasonable that this industry, which has invested in this country something over $200,000,000, be given a reasonable time until adequate rates which will preserve it can be put in force. The country has not suffered greatly by reason of this embargo. Either the industry has been extremely fair and just with the country, or else we have considerable competition within the United States among the concerns engaged in the dye industry.

For instance, I have here a comparison of prices. Here is a dye the price of which in 1917 was $1.50; in 1921, $1.80; to-day it is 95 cents.

Here is another dye. The price in 1917 was $1.22; in 1921, 78 cents; in 1922, 70 cents.

Here is another dye. The price in 1917 was $2.24; in 1921, $1.20; to-day, 68 cents.

The average price for all dyes produced in 1917 was $1.26 per pound; for 1918 it was $1.07 per pound; for 1919 it was $1.07 per pound; for 1920 it was $1.08 per pound; and for 1921 it was 83 cents per pound. That shows that by reason of the protection which has been afforded to the country in keeping out ruinous competition from abroad the industry has so developed as to gradually give to the country a lower price, which has kept pace with the development, and it is not too much to expect that if due protection is given against ruinous competition, such as Germany threatens the world with to-day, we can expect in a very few years to have a dye industry which will furnish the dyes as cheaply as they can be bought in any country in the world; but it can not be done otherwise. England has pursued the policy of protecting her dye industry. England has found herself obliged to protect her people as against the ruinous competition of Germany. The same may be said of Japan.

Outside of protecting the industry, there is the question of national defense and the question of national progress. No country can progress in these times as a first-class nation of the world either from the point of national defense or from the point of national economic growth and prosperity unless her chemistry is in the forefront and up to date with the most modern progress.

I submit, Mr. President, that that standard of chemistry can not be maintained if we permit this dye industry to perish. It is idle to say that a knowledge of chemistry which would be of substantial and practical benefit to the country can be disseminated through the colleges or the universities, or that the Government can conduct an institution for the dissemination of chemical knowledge. It can not be done. There is only one way to preserve to the country the benefits of modern chemistry, which is the spirit of the age.

Chemistry is what is governing the world to-day, both in war and in peace, and progress in chemistry can not be maintained unless you preserve an actually going concern.

I submit that this amendment ought to be adopted. Personally, I believe an embargo would be perhaps better; but this amendment is the next best thing, and this can probably be passed if those in favor of the embargo will vote for it. I submit that we can well trust the President of the United States and the Tariff Commission, under the authority provided under section 315, to reduce

these rates to what they ought to be, if they need reducing, and do it scientifically.

It has been asked why we should not leave the bill as it is and let the President raise the rate; that it can be done in 60 days. I do not believe it can be done in 60 days; but if it could be done in 60 days, the answer is that it takes no longer to reduce the rate than it does to raise the rate; and why should we have this great industry, with $200,000,000 invested in it in this country, this great industry, which is the key to the prosperity of the country, put to that burden? We ought not to have an industry which we have fostered, which was created in 1918, I believe, while the Democrats were in power, put to this burden. Really, it is the one baby which the Democrats created that is worth while, and I can not see how they can face their consciences and throw that baby out on the porch to perish.

I submit that no harm can come to the country from this. The consumer is protected. The consumer is always protected, no matter what kind of a tariff you would put on dyes. Even under an embargo he would be protected. He is protected by the competition of the manufacturer of the by-product which comes from abroad; and if anything should happen in this country to interfere with the possibility of successful manufacture in textiles, right then the market would cease for the producer of dyes.

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Mr. McLEAN. I would like to ask the Senator a question in my time. Do I understand that if this amendment is adopted the Senator from New Mexico will still favor the embargo, if it can be secured?

Mr. BURSUM. Yes; I favor the embargo. I do not think there is a chance for it, however.

Mr. McLEAN. I understand a vote on that amendment has been reserved in the Senate, and I should seriously consider the wisdom of adopting the amendment of the Senator from New Mexico as long as there is a possibility of securing the embargo.

Mr. BURSUM. I will say to the Senator from Connecticut that we had the embargo question up, voted on it, and the embargo was defeated. I notice that usually in the Senate, when once a majority of the Senate take a position and a matter is passed upon, there is hardly ever any change.

Mr. McLEAN. I merely asked the Senator's position. I understand he still would prefer the embargo?

Mr. BURSUM. Yes; I am still for it.

Mr. STERLING. Mr. President, I feel considerable interest in this question. If the question were one of embargo instead of the amendment of the Senator from New Mexico, I should vote for an embargo, as I voted for it when that question was before the Senate, for I am impressed with the belief that an embargo, or the next thing to an embargo, as near as we can have it, is necessary for the preservation of this great industry in the United States.

Mr. FLETCHER. Mr. President, I did not quite hear the Senator. Is it his position that unless these amendments are adopted he would vote for the embargo, or, if these amendments are adopted he would not feel that an embargo was necessary?

Mr. STERLING. If the embargo amendment comes before the Senate, I am not saying but that I shall support the embargo

I occupy a good deal the same position occupied by the Senator from New Mexico in that regard.

Mr. FLETCHER. This would be really an embargo in effect.

Mr. STERLING. But, thinking that the embargo may not carry in the Senate, I am in favor of the amendment of the Senator from New Mexico.

I want to call attention just briefly to two or three facts and then cite some authorities which I think ought to have a controlling influence in this discussion.

It has been charged, of course, that there was great danger of a combination; that there was an actual combination between the dye-industry people. I have the honor of being a member of the subcommittee of the Judiciary Committee which investigated the dye industry. I was unable to hear all the testimony; very much of it I could not hear because of other pressing duties, but that which I did hear convinced me that there was no combination whatsoever among the various dye industries in this country. Indeed, the witness most relied upon by those who were asserting that there was a combination or monopoly admitted that there was the sharpest competition between the various companies engaged in the production of chemicals and dyes. That witness was Mr. Metz.

Briefly, I want to call attention to a little history. Interested in this question because I was a member of that subcommittee, I looked in my Encyclopedia Britannica, the edition of 1911, and I read that fascinating history found there in regard to dyeing and the growth of the dye industry. I thought perhaps there might be something later, and I turned to the supplement, which is about up to date, and which I have lately received, and I found some references there which I think are of great importance. It is stated there—

> Previous to the war the United States had a small dyestuff industry, distributed among about five plants. The manufacturing operations, however, were limited chiefly to the assembling of the coal-tar intermediates imported from Germany for the production of the finished dyes, so that the new industry had to be built from the ground up. To the great credit of the American chemist and chemical manufacturer it may be said that in a very short time the more important dyes were successfully made in the United States in such quantity that practically no dye-consuming industry was forced to shut down by reason of a lack of dyes.

Now comes a very important suggestion. We are protecting a great body of American laborers when we protect the dye industry. I read further:

> These employed about 2,600 chemists and nearly 20,000 workmen, and the total value of the finished products amounted to over $112,000,000. There were 236 different intermediates manufactured and 360 different dyes. The total production of dyes amounted to over 88,000,000 pounds, as against a pre-war importation of about 70,000,000 pounds.

A little further on we have this:

> The great production of dyes in the United States during the period 1917-1921 led to the building up of a considerable export trade, particularly to South America and the Orient. The total dyestuffs exported from the United States in 1920 amounted in value to nearly $30,000,000, of which $22,450,000 was for coal-tar dyes. This export trade, however, showed a rapid falling off from the beginning of 1921, due both to the general business depression throughout the world and to the fact that the German dyestuff manufacturers were again active in foreign trade.

Already, then, we have the tangible evidence that the German manufacturers are taking away the American dyestuffs trade and see the signs of what will follow unless we protect our own to the

extent provided in this amendment. Then the writer of this article refers to what has been done by the other principal nations of the world in putting an embargo on dyes. He says:

In the meantime Congress was petitioned for an embargo on importation of dyes from foreign sources except under adequate license regulations which would restrict the imports to dyes not manufactured in the United States—

We all recall that provision of the emergency tariff act—

This was in line with similar action by Great Britain, France, Italy, and Japan, all these countries deeming it highly expedient to foster and build up a self-contained dyestuff and coal-tar chemical industry as a measure of national defense.

Mr. President, they did not mean this as a national defense in time of war alone, but they meant it as a national industrial defense as well. Let me quote very briefly from what is said in a remarkable letter addressed by Mr. James Morton, chairman of the Scottish Dyes (Ltd.), governor-director Morton Sundour Fabrics (Ltd.), addressed to the free-trade members of Parliament upon this question. It is alike applicable to free-trade members elsewhere. He states as follows:

But I want to refer to national defense in time of peace.

We are not in war now and we are pleading for national defense, national industrial defense, Mr. President, in shutting out to a large extent the introduction of these German cheaply manufactured dyes—dyes that will be most cheaply sold, for a time at least. He says further:

Before the war, by means quite other than her war lord or her gigantic army, Germany was silently amassing the wealth and power of the world. We reckon our textile trade and our coal and steel trades very big factors in world industry, but do we realize that before the war Germany's exports of dyes and chemicals were estimated at £97,500,000 per annum, a sum equal to about double our exports of coal at the same period, about as much as our coal and steel exports put together, and practically as much as our total exports of cotton goods to all countries.

Mr. President, do we not need to protect ourselves in industrial defense against an industrial attack such as is menacing and such as is, in fact, foretold by the statement here?

Here is a danger portrayed so clearly and vividly by Mr. Morton in this letter. He said:

But should we then, you will ask, be able really to compete with the German makers? I see no reason, when the exchange is normal and we are given bulk production, why we should not be able within reasonable time to make as cheaply and as well as the Germans; but that does not say that we could sell as cheaply as the Germans are willing to offer goods at the present time in this country. It is no use beating about the bush. The Germans would sell at any price to-day in this country to regain this market for their dyes and to extinguish our dye industry here.

In this respect he corroborates the statement of every chemist of standing and responsibility in the country who knows anything about the dye industry as to what Germany will do in the matter of selling her dye wares to the people of the United States.

As already said, they look upon organic chemistry and all its developments as their own private territory and would do anything to prevent our encroaching upon it. Instances have been given in Parliament and elsewhere to show how much less the Germans are now willing to charge for certain dyes as compared with prices here. I have no doubt about it. I go much further and will venture to say that the Germans would be willing to give us for the next year or two all our dyes free of any charge whatever, if our law would allow them. This is the real situation we have to face, and it is for us to decide whether we are willing to give ear to such overtures.

Then he relates the instance in regard to alizarin, called Turkey red dye, and how Germany, after she had broken down the English business, increased the price of that dye just six times.

One other authority, and it is one we ought to take into careful consideration, because he is a reputed free trader, is Mr. Taussig, formerly a member of the Tariff Commission. In his little booklet called Tariff Problems, I find this statement:

> There are other reasons—to digress for a moment—why the dyestuffs industry stands by itself. Not so much that it is a "key" industry; the extent to which dyestuffs dominate the textile and other manufactures is often exaggerated. But the complete control in the industry which the Germans aimed at before the war and largely succeeded in securing threatened consequences which the most convinced free trader must regard with apprehension. Combinations in the nature of gentlemen's agreements were in effect even then between the different concerns. Now, as all advices indicate, there is a firm kartell or tight combination. Here is a foreign monopoly—a real monopoly, and not merely (what is often styled a monopoly) localization in a foreign country—of an industry within which there are many competing concerns. A solid German kartell in the coal-tar industry is pretty sure to be a strenuous competitor. It will try to crush competition in foreign countries by selling at cost or below cost and then recoup by advanced prices when the competitors are destroyed. Possibilities of this sort are often paraded as a bugaboo by extreme protectionists, when the facts give little occasion for concern. But here is a case where there may be veritable need for industrial self defense.

That is from Mr. Taussig, and we ought to regard it, it seems to me, under all the circumstances, as the highest kind of testimony.

Mr. President, I think I have not much more to add. I feel that interest in this very great and important industry. It has done so much within the short time it has been in existence since the beginning of the war, produced so much of wealth for the United States, given employment to so many thousand workmen, skilled and unskilled, in the United States, it seems to me that as American citizens, with pride in our industrial development, we should maintain and encourage it in the highest possible degree.

Mr. RANSDELL. Mr. President, I favor strongly the amendment of the Senator from Arizona. It seems to me, sir, that it has in it more possibilities for good to America and the world than any other feature of the bill. In considering this amendment we must bear in mind how necessary it is to establish and maintain a strong chemical industry in America, how essential this industry is for our welfare, our national defense, and, in a more important way, our public health.

The Germans, through their investigation of coal-tar products, have developed some marvelous remedies as an incident to the dy industry. They discovered and placed on the market salvarsan, which cures one of the most loathsome and terrible diseases that ever afflicted the human race. They discovered novocaine, one of the greatest deadeners of pain known to science, wonderful in that it is a nonhabit-forming drug, a most beneficial thing. Many other very helpful drugs have been developed by the efforts of the German chemists in connection with coal tar.

I can not believe, sir, that the wise men of Germany have ever scratched the surface of the possibilities of the coal-tar industry. Coal, sir, was made by the great Chemist of nature, how many years ago none of us know, and in its manufacture everything that grows out of the ground, I imagine, was used, the most exquisite flowers, the sweetest balsams, the most healing plants and herbs o

every kind and sort, and vast forests of giant trees. Coal furnishes more commodities for the use and health and comfort of mankind than anything I know of. The wonderful violet and rose perfumes which our ladies use are manufactured from coal. Saccharine, which is five hundred times as sweet as sugar, is manufactured from coal. All the beautiful dyes we admire so much are manufactured from coal. I could tell about many wonderful things, but have not time or opportunity to do so.

It seems, sir, that we should encourage in America in every possible way this enterprise which the Germans have set on foot and from which so much benefit has come to mankind. Does anyone believe that Germans have all the wisdom of the world? Does any American doubt that our composite American population is as wise and contains as smart people as Germany? Does anyone doubt that under proper encouragement American chemists will develop just as many valuable things from coal tar as have the Germans? As the German chemists have discovered novocaine and aspirin and salvarsan, why can not American chemists discover remedies for cancer and leprosy and that most fatal of all diseases—tuberculosis? Great efforts to that end have already been made by American chemists. Let us encourage them in every possible way. American doctors have in the last 25 years demonstrated that they can do wonders in treating diseases. American doctors discovered the cause of hookworm and pellagra and treated them successfully. They found out that the Stegomyia mosquito was the cause of yellow fever and have practically eradicated that dread disease throughout the world. All we need to do, sir, is to give proper encouragement to American chemists and they will, in my judgment, prove by their medicinal discoveries just as beneficial to America and to the world as ever the Germans have been, and as helpful to suffering humanity as their brethren in the medical profession, for I can not believe that all the secrets in the interest of health hidden by the Architect of the Universe when He created coal have yet been unearthed. There are many secrets still hidden. Let us discover them, or at least let us try to discover them. This is only one phase of the case.

Many people say, and I agree with them, that the next war, if war must come—and unfortunately it has always come to the world—will be a chemical war. America must be ready for it at home. She must develop her own chemical resources and not depend upon other countries. She must create a great chemical industry, and make all known combustibles in order to be prepared for a possible war.

This matter of national defense is only one of many important things which can come from the development of the coal-tar industry. I sincerely hope, sir, that the amendment will be agreed to.

I now yield to the Senator from New Hampshire, if he still wishes to ask me a question?

Mr. MOSES. I merely wished to ask the Senator from Louisiana if he desired the chemical industry of this country to develop to the extent where saccharine would replace sugar?

Mr. RANSDELL. I do not think it is probable that it will at all interfere with the sugar industry of my State, I will say to the Senator, but if it can be made cheaper, and the good people of America can get the sweetening which they need from saccharine, I say, "Well and good, my friends; I want you to have just as cheap

sweets as you can get," and, as one of the Senators from Louisiana, I will take my chances on saccharine as a competitor with cane sugar.

Mr. President, in conclusion, I ask permission to publish at the end of my remarks, without reading, a very interesting letter from Prof. Charles E. Coates, dean of the department of chemistry in the Louisiana State University at Baton Rouge.

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LOUISIANA STATE UNIVERSITY,
DEPARTMENT OF CHEMISTRY, AUDUBON SUGAR SCHOOL,
Baton Rouge, La., August 9, 1922.

Senator J. E. RANSDELL,
United States Senate, Washington, D. C.

MY DEAR SENATOR RANSDELL: A few days ago my attention was called to the fact that the question of the embargo on German dyes was coming up soon for final action and that the bill was in danger. The matter seemed to me so important that I went to New Orleans last Saturday and called a meeting of the executive committee of the American Chemical Society to discuss the question. I was in consequence requested to write you and Senator BROUSSARD in my capacity as national councilor for the American Chemical Society, but I have decided that it would be best for my letter to be personal, inasmuch as official statements are frequently discounted in advance.

I would not presume even to attempt to argue a matter of this sort, to which you have doubtless given very serious thought, but as it is so highly technical and at the same time so important, in ways which are both direct and indirect, I shall venture to call to your attention the views and convictions of every chemist with whom I have ever discussed the subject.

The American Chemical Society, as you probably know, is possibly the strongest scientific society in the world and is not in the least interested in dyes, per se, only a few of its members having anything to do with dyes professionally. But inasmuch as chemistry is a growing science which changes from day to day, all chemists of any consequence must keep abreast of chemical progress, and for this reason the status of the dyestuff industry has been well known to us for the last 20 years or more. During that time we have seen the development of the German industry and the crushing of its competitors in France, England, and America. As long as we considered this merely a matter of business we regretted our failure and thought little more of it, but when the first few months of the war showed us that it was to be a chemical war we realized suddenly what we should have known all the time, and that is that the dyestuff laboratories were the only schools in which a sufficient number of men would get that training in advanced organic chemistry which was necessary for the manufacture of ammunition and for the making of synthetic drugs. We believe to-day that the existence of this industry is an essential part of our national defense, and we look upon it therefore as a subject which should not be made a party matter but should be considered purely from a patriotic standpoint.

There is in addition the business end of the matter and this, too, chemists have been compelled to study, and they have discovered with astonishment the methods used by the German Dye Trust, which came within an ace of complete success. We are, therefore, on the lookout for German propaganda which would naturally try to make this subject a party matter if it could, just as it will naturally try to induce the President to proceed against the Chemical Foundation if it can. As I said, the whole question is so very technical that it would require years of study to master it, and for this reason it is the more significant that every chemist of my acquaintance, none of whom have one dollar's interest in dyes, are unanimously of the opinion that if Germany is allowed to send its excess dyestuffs to this country during the next three or four years it can sell them at a figure which will absolutely destroy the dyestuff industry in this country, a figure which, in fact, might well be much below the cost of production even in Germany.

It takes at least 8 or 10 years to train a man in chemistry to the point where he will be an efficient chemist in a dye works. Moreover,

if 100 men should start out to take this training the nature of the training is such that not more than 5 would prove able, intellectually, to master the subject and to do efficient work. Of these five, in the course of six or eight years more, perhaps one man would have proved his ability to do creative work and this one man would then be a national asset of enormous value in time of peace as well as in time of war. The process is so slow that if the industry is once destroyed it could not be built up again in less than 10 years, and probably would not be built up at all, because no one would put capital into a losing venture. All the chemists of my acquaintance know this and know that Germany knows it. For the last eight years we have been building up the dyestuff industry in this country. It has made remarkable progress, but it is not yet able to stand alone. How much longer it would take is a matter of opinion; certainly three or four years, at the end of which time the return of normal conditions abroad will have prevented the accumulation of an excess stock of dyestuffs, and a moderate tariff would suffice for the protection of our industry. At present, however, the excess stock of foreign dyes has absolutely no value unless it can be used, for which reason the German dye trust could well afford to give these dyes away or even to offer a bonus for taking them, if by so doing they could not only crush out immediate competition but at the same time obliterate the American dyestuff industry. With the loss of this industry would come the loss to our country of the trained organic chemists whom we sorely need; but it is evident, in addition, that once our industry is destroyed, the German dye trust can advance prices and recoup itself with no fear of successful competition.

Chemists, therefore, are of the unprejudiced belief that there should be an embargo placed on foreign dyes which should not be removed for any particular dye until the possibility of the process known as dumping could no longer exist. We believe this to be a question which is national in nature and should not be made a party question. We particularly call attention to the fact that as a class we are competent to judge in this matter, that we are without financial interest of any sort, and that we are activated in taking our position only by what we consider to be the best interests of our country, not only at the present time but particularly in the future.

Very truly yours,

CHARLES E. COATES,
Counsellor Louisiana Section, American Chemical Society.

Mr. MOSES. Mr. President, if the amendment offered by the Senator from New Mexico [Mr. BURSUM] singled out from paragraphs 25 and 26 of the bill those articles which require extreme protection, I should not object to it. The vice of the amendment, however, is that it includes every article upon the list, not only those which are delicately and with difficulty procured from the coal-tar distillates, but those which are produced in tonnage proportions. It includes those which are sold at 5 cents a pound, if such there be, and those that are sold at $5 a pound, and there are many of those. That, Mr. President, is the vice of the amendment. I think, also, that so far as those particular products which require extreme protection are concerned it will be found that they are adequately protected in the amendment which was adopted here the other night applying, in the wisdom of the President, the American valuation to these products. I think that any Member of this body with a piece of chalk and a barn door can prove it impossible to land in this country any product covered by the paragraphs below the American selling price.

Mr. WADSWORTH. Mr. President, as a part of my remarks, I ask that a letter written by the Secretary of War to the chairman of the Committee on Finance, the Senator from North Dakota [Mr. McCUMBER], may be read by the Secretary.

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WAR DEPARTMENT,
Washington, August 15, 1922.

CHAIRMAN UNITED STATES SENATE FINANCE COMMITTEE,
Senate Office Building, Washington, D. C.

MY DEAR SENATOR MCCUMBER: On July 26, 1921, I wrote your committee, calling attention to the fact that the Fordney tariff bill would not protect the American organic chemical industry from destruction by German competition. Allow me to reiterate the importance of the preservation of this industry to the country from the standpoint of national defense.

The dye industry is the backbone of the organic chemical industry, on which all Governments are dependent for their high explosives, their medicines, and other materials. Inasmuch as the coal-tar industry, which is the basis of all dyes, is also the basis of all high explosives and of synthetic medicines, it is of vital importance to preparedness that the dye industry be developed to the fullest possible extent in this country. The use of explosives will be far greater in any future struggle than in the World War.

Notwithstanding that from 1914 to 1917 our great steel industries and our rapidly developing chemical industries had been working feverishly to increase their facilities to supply ammunition, guns, and rifles to the Allies, it was more than a year after we entered the war before those industries were able to supply ammunition, guns, rifles, etc., to meet the American needs. Even then our chemical industry was so undeveloped in 1917 that it was necessary for the Government to build large high-explosive plants and powder factories.

Germany realizes the importance of predominance in organic chemical industries as a most valuable means of preparedness and has formed of them one great trust. The German trust can produce dyes and similar material so much cheaper than the Americans produce them that no ordinary tariff can prevent the destruction of the American industry, which will thereby cripple the whole organic chemical industry.

It is, therefore, urged that the dye-control provisions of the emergency tariff act of 1921 be extended another year to give the industry a chance to stabilize and to enable conditions in the dye industry to be carefully observed and the products determined which should be protected in order to firmly establish that industry in the United States.

Very truly yours,
JOHN W. WEEKS,
Secretary of War.

Mr. WADSWORTH. Mr. President, it is apparent, of course, that the concluding paragraph of the letter of the Secretary of War is not applicable to the amendment which is now pending, because in that paragraph the Secretary urges the continuation of the selective embargo at present in force. I thought, however, it would not be amiss that the letter of the Secretary in which he discusses from the standpoint of the national defense the value of the organic chemical industry be placed in the RECORD at this time. I think that not even the most suspicious-minded man will accuse the Hon. John W. Weeks of being impelled by unworthy motives when he urges upon Congress the consideration of the chemical industry in connection with the defense of the Republic.

It is quite possible, Mr. President, that a good many Senators do not feel as deeply upon this subject as do I. Perhaps I feel too deeply upon it; I do not know; but, such as my feelings are, I intend to express them upon this occasion as briefly as possible.

From what I have been able to learn of the history of organic chemistry in this country, especially in the dye industry, prior to our entrance into the World War, during our participation in the war, and since the war, I am convinced that long before the United States actually declared a state of war the German Government and the cartel were in effect, although slyly, waging war against the peace and the safety of the people of the United

States. We did not wake up to that situation until we ourselves got into the fight. The letter of the Secretary of War points out very briefly—all too briefly, according to my view—but sufficiently for the purposes of this discussion the predicament in which this Republc of ours found itself when we were called upon to engage in our own defense.

Manipulations of the German cartel in the matter of patents, the immense influence, politically and otherwise, which they maintained in this country before the European war must now be known to every sensible man. Their effort was deliberate; it was skillful, and it was successful up to a certain point. That effort was directed toward making and keeping the American people as helpless as possible in the event of any great crisis overtaking them in which the German Government might be a party.

We went into the war and we learned the lesson at the cost of billions of dollars and many thousands of lives. We participated in the great victory and at the conclusion of the contest we asked for no territory; we asked no reparations; we asked for nothing of value to be taken from the vanquished and we received nothing. The only thing which has come to the people of the United States of material value as a result of their efforts and sacrifices in the Great War is peace and security in the future and the guaranty of self-maintained public health; not one other thing or opportunity of a material character has come to this great people of ours out of that war.

We have the opportunity, as the result of the contest, an opportunity seized upon legally to maintain our public health with our own resources and without depending upon any foreign government or any foreign cartel, corporation, or trust. We have secured the opportunity—and have secured it legally and properly as a result of our sacrifice and our efforts in the war—to maintain our national defense without depending upon any other nation, government, trust, or cartel of any kind whatsoever. That is the prospect which confronts the American people to-day.

Mr. President, I am not surprised that far-reaching efforts have been exerted in this country for the last two years once more to reduce us to that condition of comparative helplessness in which we dreamed and dreamed and dreamed in 1916. I am well aware of the influences which have been brought to bear here in Washington; I am well aware of the source of those influences; I know perfectly well that if this cartel can once more establish its domination over the organic chemical industry of the United States, such as it enjoyed prior to our entrance into the war, the enemies of America, actual and potential, will rejoice.

I question not the motives of Senators who do not see this question as I see it; without doubt they are sincere; but it passes my comprehension how they can fail to read the signs of the times. If there ever was a deliberate attempt to break down, to undermine, to weaken the power of American self-defense, it has been made in connection with the American organic chemical industry.

It does not do, Mr. President, in discussing this matter, to drag the names of American citizens into the discussion and accuse them of dishonest motives because, forsooth, they take an interest in the perpetuation of this chemical industry here in America. It does not do, Mr. President, to bring inferences and insinuations

against Francis P. Garvan; not by any means. I care not what his politics are; I understand he is a Democrat; I have known him since 1895 and known him well. He is an honest man, and he has no thought in his mind or motive in his heart except the safety of this country. It does not do to bring unfair inferences and insinuations against men like Otto Bannard, of New York, who is one of the trustees of the Chemical Foundation, for he is an honest man, with no thought except the safety of his country.

I shall not discuss upon this occasion the wisdom or the unwisdom of the policy adopted by the last administration in the handling of the patents covering the dyes through the Chemical Foundation as trustee; that is not a part of this discussion; but I know full well, if I know anything about the psychology of this situation, that the attack upon the Chemical Foundation had a most material influence upon the votes cast on the question of the tariff on dyestuffs. It is for that reason that I deplored it at the time, although not publicly, for I had no opportunity to do so, but I deplore it now. It is not the question at issue.

Mr. President, as I said in my opening sentence, I feel deeply on this question. I believe that there is involved in it one great issue: America safe against attack from without and safe in the matter of public health, or America dependent upon some outside power and influence in the matter of its self-defense and in the matter of its public health.

This organic chemical industry lies at the bottom of nearly everything we use. I firmly believe that the progress of the race from now on will be measured more by the progress in organic chemistry than in any other human effort. I believe that in organic chemistry lies the solution of the secrets of the past and of the future. I believe that its establishment and maintenance in this country, even under an embargo, mean the happiness, the progress, and the security of 100,000,000 people. No rate of duty will frighten me and no embargo will frighten me.

I notice that England has put an embargo against the importation of dyestuffs. I notice that France has done the same thing. I notice that Italy has done the same thing. I notice that Japan, if she has not already done so, is about to do so. They have awakened to the significance and the importance of organic chemistry. I pray that the time will come when American public opinion will come to an appreciation of what organic chemistry means, of what research means, in the way of progress. We have been interested as a people in the development of material resources —the digging of iron and coal from the ground, the raising of crops upon the surface, and the engaging in transportation and other forms of commercial effort. As a people we have paid little attention and given little encouragement to scientific research, but, Mr. President and Senators, the progress of the future depends upon scientific research. It is the man working in the chemical laboratory who is to blaze the way for human progress.

I want to see the chemical laboratories of this country multiplied again and again. They can not be multiplied, they can not be maintained, no student will attempt to attend their courses, unless there is a chemical industry in which those students upon graduation may find a career.

The two things—research in the laboratory and the successful conduct of a chemical industry—go hand in hand. Neither can proceed without the other.

I regret that the Senate voted down the selective embargo. I think it made a mistake. I was in the minority upon that proposition. That is my first choice as a remedy. The Senator from New Mexico [Mr. BURSUM] has offered an amendment which, in my judgment, is next best. It will give some chance, at least, for the survival of this industry of ours, which already bids fair to be able to meet the demands of our people, although it has only been devoted to its task for three or four years, and research was almost unknown in this country. I think that industry will get a decent chance to survive under the amendment offered by the Senator from New Mexico. Feeling as I do upon this question, feeling that it is vital to the security and the happiness and the contentment of this great Nation, I beg for its adoption.

Mr. MOSES. Mr. President, the Senator from New York [Mr. WADSWORTH] can not possibly be more sincere in the position which he occupies than I am in that which I occupy. The Senator from New York can not have higher respect for the Secretary of War than I have. On the record, I doubt if the Senator from New York can qualify as well as I can, because the Senator and I both happened once to sit in the same Republican National Convention, and I voted twice for the Secretary of War as a candidate for President, and the Senator never voted for him at all.

This is not the first letter which the Secretary of War has signed with reference to the embargo; and I say "signed," Mr. President, because I happen to know that the first letter was not written by him, and I wonder if he wrote this one, and if he knew everything of its implications.

Mr. WADSWORTH. Mr. President, does the Senator really wonder about that?

Mr. MOSES. I doubt very much, Mr. President, if the Secretary of War, with all that he has to deal with, can possibly go into the ramifications of this subject.

Mr. WADSWORTH. I shall be most interested when the Senator from New Hampshire visits the Secretary of War and makes that suggestion to him. I should like to be present.

Mr. MOSES. I probably shall.

Mr. WADSWORTH. I doubt if the Senator will.

Mr. MOSES. The Senator is entitled to that opinion.

Mr. President, as for the influences, the exertions that are at work and that exist in Washington with reference to this measure, they are patent to everybody. We have seen them without number. We have seen, yesterday and to-day, the Capitol invaded by a horde of men bearing in their lapels the label "Chemist." I suppose, Mr. President, the way to become a chemist in this country is to put a label in your lapel. We have seen the exigent importunities of the Synthetic Organic Chemical Manufacturers' Association—an association known in the trade as the S. O. C. M. Association, the "Soak-'em" association, an appellation, Mr. President, which well befits their activities—and the sole question here is whether the items of protection already voted in this bill will sufficiently protect the chemical and dye industries of the country.

I hold that they will. I hold that the chemical and dye industries of the country are not sacrosanct; that they do not have to be singled out for special favor; that they may be developed behind the wall of a protective tariff as well as the tin-plate industry or

the silk industry or any other industry that thrives in this country.

Mr. President, I wish to say in conclusion only that I am as eager as the Senator from New York to see the chemical laboratories of this country in full operation and manned by an entirely efficient personnel, and that if the chemical and dye manufacturers of the country would spend half as much time, half as much money, and half as much effort in their laboratories and in their factories in developing their processes and their products as they have spent in Washington in the last two years seeking special privilege we would not have such a question as this before us.

* * * * * *

Mr. SMOOT. Mr. President, I doubt whether any Senator has taken as much interest in this schedule as I. I have given days and nights and weeks of time to its consideration. No Senator wants to permit this industry to live more than I. The rates reported to the Senate in the dye paragraph, 7 cents a pound specific and 60 per cent ad valorem, granting to the President power to increase those rates from 50 per cent and transferring those rates from a foreign valuation to an American valuation, is virtually an embargo. The embargo was bad enough, but the proposed amendment is even more vicious and indefensible than the embargo.

I will take the six items which the Senator from New Mexico pointed to as evidence to show that there should be a duty higher than that imposed in the bill, and I want the Senator to follow me and see the result. The Senator from New Mexico pointed to six of the items in the bill, and he said that the American price on the first was 90 cents a pound, the foreign price 29.2 cents; the second, 90 cents, American price, and the foreign price 44.8 cents; the third, 55 cents, American price, and the foreign price 9.4 cents; the fourth, 25 cents, American price, and the foreign price 16.6 cents.

The fifth was 30 cents, as the cost in America, and in the foreign country 18 cents; on the sixth 80 cents was the cost in America, and the foreign price was 31 cents.

The average American cost of these six items is 61.66 cents a pound.

The amendment proposes to put a duty of 90 per cent and 10½ cents per pound upon those items, and 90 per cent of 61.66 cents is 55.49 cents. Then there is a specific duty of 10½ cents, making 65.99 cents.

The average of all of them is 61.66 cents; so, in order to get one of the articles named into this country, Germany, or any other country, would have to give the article away and pay the importer 4⅓ cents to get it into this country.

Embargo? If it was only an embargo, if they could give the product away to get it in, that is embargo enough. But the amendment provides more than that; they would have to give 4⅓ cents upon every pound of the articles coming into the United States before they could ever enter this country.

Mr. REED of Missouri. I do not want to interrupt the Senator further than to say that the argument he is now making will apply to every item in this bill.

Mr. SMOOT. I do not agree with the Senator, and, not only that, neither the Senator from Missouri nor anyone else can prove it.

Mr. REED of Missouri. I can come mighty near proving it.

Mr. SMOOT. I will say to the Senator that I do not agree with him.

Mr. WADSWORTH. Mr. President——

The PRESIDING OFFICER. Does the Senator from Utah yield to the Senator from New York?

Mr. SMOOT. I yield, but I do not want to take too much time.

Mr. WADSWORTH. Just for a question.

Mr. SMOOT. I have not very much time.

Mr. WADSWORTH. Putting aside for a moment the question of a duty, and the prices and cost figures which the Senator is quoting, which I am not going to discuss, what will happen between the time of the passage of this act and any future possible raising of the rate by the President?

Mr. SMOOT. I am going to ask the Senate that the 60 days be stricken out and 15 days be inserted. The original amendment provided for 30 days. No one thought that in 30 days importers could get any great quantity of goods into this country; but I am willing to make it 15 days.

Mr. WADSWORTH. What sort of an investigation can be made in that period?

Mr. SMOOT. It is not the investigation; it is after the proclamation of the President that the added rates take effect.

Mr. WADSWORTH. How long will it take to make the investigation?

Mr. SMOOT. I can not say as to that.

Mr. WADSWORTH. That is the important thing.

Mr. SMOOT. I think the investigation is already being made.

Mr. WADSWORTH. By whom?

Mr. SMOOT. By the Tariff Commission. I do not think there is any question about it.

I want to say that 7 cents a pound and 60 per cent ad valorem on the foreign valuation is an absolute embargo upon 80 per cent of the dyes manufactured in this country.

Mr. POMERENE. What would it be on the American valuation?

Mr. SMOOT. It would increase that amount.

Mr. POMERENE. About how much?

Mr. SMOOT. I mean the amount of production. It would increase it up to 90 per cent. Let us take some of the items in general use and apply the proposed amendment.

Mr. SHEPPARD. Did the Senator base his last statement on the bill as reported, and not on the amendment?

Mr. SMOOT. The amendment as reported to the Senate. Let us take some of the items; for instance, synthetic indigo. Right after the war, when the manufacturers of synthetic indigo came here demanding the first embargo, it was selling for 75 cents a pound. Your committee was told that in no case whatever could it be made and sold for less than 65 cents a pound. It was being exported at 75 cents a pound. But 65 cents a pound was the lowest that it could be made for, according to them. I know that they are selling it for 22 cents a pound to-day.

Mr. WADSWORTH. That is to their credit, is it not?

Mr. SMOOT. It was not to their credit to try to make the committee believe a year and a half ago that it could not be sold for less than 65 cents, since what has taken place of late.

Mr. WADSWORTH. You were not discussing tariff rates; you were discussing an embargo, to give them a chance to make the researches.

Mr. SMOOT. Eighty-five per cent of the items have nothing to do with medicine.

Mr. WADSWORTH. I am glad to know the embargo reduced the price of that one thing. That is what I have always suspected would happen.

Mr. SMOOT. I suppose the Senator from New York would. What will happen if this amendment is agreed to?

Mr. LODGE. Mr. President——

Mr. SMOOT. I have but a few minutes. I hope the Senator will let me go on.

Synthetic indigo is selling for 22 cents. Ninety per cent of 22 cents is 19.8 cents. The balance is 2.2 cents. Then we have a specific duty of 10½ cents a pound, and 2.2 from 10½ leaves 8.3. In other words, no man can get that product into the United States, if this amendment goes into effect, unless he pays 8.3 cents for the privilege; yes, give it away and pay that amount to get it in.

Take the next article produced in great quantity in the country, acid black. To-day's price is 12 cents. Ninety per cent is 10.8, leaving 1.2 cents. With 10½ cents specific duty, deduct 1.2 cents, which would leave 9.6 cents that the exporter will be compelled to give besides the goods to get them into the United States.

Mr. President, the only reason I supported the rates as the committee reported them was because I want the small per cent of the products necessary for the defense of our country in time of war produced here. I have a letter admitting that it is only about 2 per cent, but suppose it was 15 per cent; I want the embargo in the form of rates, and I say now that if we have the power given the President, with 7 cents a pound and 60 per cent, increasing, under the American valuation, to 50 per cent, as provided for in the bill, this is what would happen: Suppose an item was $2 a pound, and suppose that same item sold for $20 a pound in the United States; 90 per cent of $20 is $18, and deducting that from $20 it leaves $2, and 10½ cents a pound leaves $1.89½. So, Mr. President, if the foreign price were $2 a pound and the price in this country were $20, under the provisions of the bill they could not get a pound of such produce unless they would give it away and pay the 11½ cents besides.

I am perfectly willing to do everything for this industry that any man on earth can do, but why take the whole industry and impose a duty of 10½ cents specific and 90 per cent ad valorem when there can not be a case pointed to where it does not amount to an embargo?

I want the President to have the power to impose an embargo upon certain articles. Let the President designate particular products which shall be assessed on the American valuation and bear not only the rates provided for in the bill but an increase of 50 per cent over and above them.

Mr. President, when the proper time comes I want to strike out "60 days" and insert "15 days," as I stated, so that it will read in this way:

> But no such rate shall be decreased or increased more than 50 per cent of the rate specified in Title I of this act upon such merchandise—

Which refers not only to paragraph 26 but to paragraph 25—

> Such rate or rates of duty shall become effective 15 days after the said proclamation of the President.

Mr. JONES of New Mexico. Will the Senator please read a little louder? We can not hear just what his proposal is.

Mr. SMOOT. I have not the time to read it again. I want to say to the Senate at this time that Mr. du Pont was a very fair witness before the committee. He told the committee that he did not want an ounce of dyes or chemicals to come into this country from any place on earth—not one ounce. He made the statement to me yesterday that that was his position now, and he wanted not only an embargo in every sense of the word, but he thought that it was absolutely necessary to build up the industry.

If I thought it was necessary to build up the industry I would not hesitate to vote for it. But I know it is not necessary.

Mr. DU PONT. Did Mr. du Pont give a written statement of his position?

Mr. SMOOT. Yes; he stated here——

Mr. DU PONT. Why does not the Senator read that?

Mr. SMOOT. Certainly; if the Senator wants me to read it, I will read it. After discussing the embargo and saying that an absolute embargo was the only thing that would preserve this industry, Mr. du Pont reiterated what his testimony was before the committee, that he did not want a single ounce of it to come into this country, and made this statement, and this is in his own writing, made yesterday. The Senator wants me to read it, and I will do so:

> The present proposed duty upon coal-tar dyes does not protect the industry, and is therefore useless. This because the power given the President to increase the duties can not be invoked in time to prevent the importation of large quantities of German dyes.

In the amendment we provide 60 days. I have already announced to the Senate——

Mr. WADSWORTH. Will the Senator yield there just a moment? Is the Senator accurate in that?

Mr. SMOOT. In what?

Mr. WADSWORTH. Does not the 60-day provision apply to the period after the proclamation is announced?

Mr. SMOOT. Certainly.

Mr. WADSWORTH. But what happens before the proclamation is announced?

Mr. SMOOT. Nobody in Germany will know what the proclamation is going to be.

Mr. WADSWORTH. It would certainly be a raise, not a lowering.

Mr. SMOOT. I do not know about that. I say that if an investigation were made upon 85 per cent of these, there would be a lowering.

Mr. WADSWORTH. I disagree with that, of course.

Mr. SMOOT. The Senator may disagree with it, but I can prove it to the Senator, if he will take the prices of to-day.

Now, Mr. President, I do not care to say anything more. In fact, I did not intend to say this much.

Mr. LODGE. Mr. President, I want to be clear about the 15 days. Can the President make the proclamation until the investigation has been had?

Mr. SMOOT. Why, no.

Mr. LODGE. The investigation has to come first?

Mr. SMOOT. Certainly. The bill provides:

That the ad valorem rate or rates of duty based upon such American selling price shall be the rate found upon said investigation by the President to be shown by the said differences in conditions of competition of trade in the markets of the United States necessary to equalize the differences so found in said conditions of competition in favor of either foreign manufacturers or producers, but no such rate shall be decreased or increased more than 50 per cent of the rate specified in title 1 of this act upon such merchandise.

Mr. LODGE. I did not mean to have the whole bill read. I wanted to find out when the President should make his proclamation.

Mr. SMOOT. It provides further:

Such rate or rates of duty shall become effective 30 days after the date of the said proclamation of the President.

Mr. LODGE. He can not make the proclamation until the investigation has been made?

Mr. SMOOT. Why, no.

Mr. LODGE. I have here a letter dated August 16 from the Tariff Commission, which I shall ask to have printed in the RECORD, and in which this statement is made:

The time required for such an investigation is uncertain, but from experience gained in other chemical investigations we believe it will require from 8 to 10 months to make a satisfactory report on the subject.

During those 8 or 10 months, of course, the dyes would come in.

Mr. President, I did not mean to enter into this discussion. I took no interest whatever in the matter of rates or whether we keep out all other dyes or not. I have but one single interest in the question, which is derived from some years of experience in the Senate. I endeavored back in 1909, in conjunction with the Senator from Utah, to get some protection which would tend to give us an independent chemical production. We failed. We got into the war. We had no chemists who could furnish us with explosives and later with the gases. It was the same in England, which was then believing in the phantom of free trade. She found herself in the same condition. No one can possibly tell what that disadvantage, which weighed down upon both England and the United States, cost us in men, money, and time in the winning of the war. I made up my mind that, so far as I was concerned, I would use every effort in my power to see that the United States was never left again defenseless in that way.

I voted for the embargo when it was proposed by the Democratic Party. I voted for it during the war. I continued to vote for it when it was continued when the Democratic Party had not yet gone out of power. I voted for it for the sole reason that I wished the country to be independent in the matter of organic chemistry.

No matter what it may cost, it is something that is worth any price they choose to pay to make the country independent in that direction.

Mr. President, I voted for it again for the same reason. It does not weigh with me that the dyes can come in at this price or can come in at another price. I want to do what the other countries have done who have learned something from their experience. I want this country to see to it, by tariff or embargo or in any other way, that organic chemistry in the United States is put in a position where we shall never find ourselves in the condition in which we were before. I am speaking not in the interest of any industry. I have not been approached by anybody representing an industry in that respect. I know the interests that are here. I have heard of the representatives of the German importing interests rejoicing in the lobbies here when the embargo was beaten the other day. I have taken this long interest in it for these years for but one reason, and I vote for this provision to-night for but one reason, and that is national defense and safety.

Mr. President, I ask that the letter from the Tariff Commission may be printed in the RECORD.

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UNITED STATES TARIFF COMMISSION,
Washington, August 16, 1922.

Hon. J. S. FRELINGHUYSEN,
United States Senate, Washington, D. C.

MY DEAR SENATOR: We have your letter of August 15, in which you request the opinion of the Tariff Commission as to whether foreign costs of production in the dye and synthetic organic chemical industry can be obtained, and if so, what length of time will be required to complete an investigation sufficiently comprehensive for the purposes of section 315 of the pending tariff bill.

The commission is of the opinion that it is improbable that foreign costs of production can be obtained in any reasonable time from the cost records of foreign chemical manufacturers, especially those in Germany. It is probable, however, that cost data sufficiently accurate for the purposes of the pending bill can be made by chemists and accountants in the foreign field who are familiar with the manufacturing processes, labor conditions, costs of raw material, and the market price of the finished product.

The time required for such an investigation is uncertain, but from experience gained in other chemical investigations we believe it will require from 8 to 10 months to make a satisfactory report on the subject.

In reply to your request for the quantity and variety of dyes and other synthetic organic chemicals imported during 1921, we submit the following figures taken from the Census of Dyes and other Synthetic Organic Chemicals, 1921, a copy of which is inclosed. The total imports of coal-tar dyes were 3,914,036 pounds, valued at $5,156,779. Over 1,300 trade types were imported, as shown in detail beginning on page 91 of this report. The total quantity of dyes imported, in which most of the vat dyes are reduced to a single-strength basis, was 4,252,911 pounds.

In regard to the imports of other synthetic organic chemicals during the year 1921, the Department of Commerce lists separately only a part of those imported. The imports of these products, according to the partial list reported by the department, were 2,534,262 pounds, valued at $426,393. For further details we refer you to Tables 28 and 30, pages 155 and 156, of our census report referred to above.

If we may serve you further in this matter we shall be glad to do so.

Very truly yours,

THOMAS O. MARVIN, *Chairman.*

Mr. JONES of New Mexico. Mr. President, we have been discussing the bill for four months. We have developed the fact that there are many difficult problems with which to deal. Some

of them, in fact most of them, I think, are being dealt with in the dark. We do not know what is going to be the effect of the action which we have taken, in my judgment, regarding the vast majority of the items in the bill. Confronted with these conditions, I have proposed an amendment. I offered it in the first place as a substitute for the bill that would leave the law where it was until we got sufficient light to intelligently change it. I believe now that is the course which we should take both for the welfare of the industries of the country and for the welfare of the country itself.

The discussion regarding the item demonstrated the wisdom of the amendment which I offered. We do not know what are the facts regarding the industry. We do not know the effect which it would have upon the textile industries of the country. We do not know the effect which it would have upon the chemical industry of the country. We are dealing in the dark. I do not believe in this kind of legislation. I do believe that before the Congress acts it should know what the facts are and have some information as to what the consequences would be. Regarding the industry we do not know either. We do not know what the facts are, nor do we know what the consequences would be.

I have been opposed to an embargo upon general principles. I am opposed to it now. An embargo means that the Government of the United States shall take under its wing the particular industry and manipulate its affairs according to its judgment. These are the principles which have actuated me in the discussion of the bill and in the votes which I have cast hitherto upon the question of the chemical industry and dyestuffs.

But my mind reverts to that time when the European nations were at war, when the industries of the United States were clamoring for dyes. I remember when I was in the Interior Department the agencies of the President of the United States were asking the manufacturers of the country to come to Washington to work out some plan whereby the organic chemical industry of the country could be organized and sustained for the benefit of the country as a whole. At that time we were in dire distress. These men came to Washington.

There was conference after conference, and even the then President of the United States, after considering the situation, virtually promised them the help of the United States if they would engage in those industries, if they would establish them and produce those things which were necessary for the welfare of the country. I recall those anxious days. What we should do now I do not know and you do not know. I venture to say that there is not a Senator within the sound of my voice who knows what it would cost to produce the different dyes, who knows what the profits would be under one rate of tariff or under another rate. We know nothing about it substantially. Certainly we do not have that clear and certain information which ought to guide the legislator in using the taxing power of his country. We do not know. But I do know that these people entered upon this industry with the virtual promise of their Government that they would be able to survive.

In these circumstances, Mr. President, I am willing to give the industry the benefit of the doubt. I do not know just what that will mean. I do not know how much profit it will put in the coffers of these corporations. But I do know that the Congress

of the United States will be in session practically all the time from this period forward, and we can ascertain.

* * * * * *

However, Mr. President, here is an amendment which I think concerns a so-called key industry; I think it is an industry which is essential for the welfare of the country; I think it had the moral promise of support by this Government; and while I do not know what my vote may mean I am willing to give to this industry the benefit of that vote, and I am going to support the amendment.

Mr. SIMMONS. Mr. President, I have only a few words to say in reference to this matter. When the Senator from New Mexico offered his amendment I asked him if the amendment in effect did not mean a substantial increase in the tariff rate prescribed for dyestuffs and if it did not substitute the American for the foreign valuation scheme. He answered that that was what the amendment meant.

Mr. President, a mere cursory consideration of the change in rates proposed by the amendment of the Senator from New Mexico shows that he proposes to increase the rates which are now in the bill from 33⅓ to probably 50 per cent. This side of the Chamber have voted every time the question has been presented against the rates that are now written in the bill. If they shall, therefore, vote for this high rate, they will be reversing themselves.

Secondly, the rates against which we have voted and which have been increased from 33⅓ to 50 per cent were based upon foreign valuation. If we shall now vote for the Bursum amendment, we shall vote not only to increase those rates from 33⅓ to 50 per cent, but, by substituting American valuation for foreign valuation, we shall practically vote to increase the rates in the pending bill more than 100 per cent.

Under those circumstances I can not believe that Senators on this side of the Chamber who have voted against the rates on dyestuffs which are contained in the bill based upon foreign valuation are now going to vote to increase those rates 33⅓ to 50 per cent and then base them upon the American valuation. I think a vote of that sort would be a vote of self-stultification, and I appeal to Democrats—I do not care what Republicans may do about this matter—but I appeal to the Democrats on this side of the Chamber not to stultify themselves in such a way as that.

Mr. EDGE. Mr. President, just a word. My colleague the senior Senator from New Jersey [Mr. FRELINGHUYSEN] is unavoidably detained from this session of the Senate. As all the Members of the Senate very well know, he has, with facts and statistics at hand, I might say, led the fight for proper protection for this great industry in this country. Personally I feel, without any hesitation, that the embargo is in every way justified. I shall vote for an embargo, as I have before voted for it, if an opportunity is afforded; but I feel that the pending amendment certainly offers that much additional protection to this great industry, which employs so many thousands of men and which has been organized and developed during times of stress, and, to a great extent, at least, will afford the protection which is necessary. For that reason I shall support it.

I am sorry my colleague is not present to-night, because he has

made such an exhaustive study of all the facts surrounding the necessary protection to this industry that I am sure the Senate and the country would have been benefited by the views which he would have expressed had he been present.

As I have said, I shall support the amendment simply on the conviction that it is an additional step in the direction of a proper protection to an industry which deserves the support and the protection of Congress at this time.

The PRESIDENT pro tempore. The question is on the amendment of the Senator from New Mexico [Mr. BURSUM].

* * * * * *

The result was announced—yeas 38, nays 23, as follows:

YEAS—38.

Ball	Edge	McNary	Sheppard
Brandegee	Ernst	Myers	Shortridge
Broussard	France	Nicholson	Stanfield
Bursum	Gooding	Norbeck	Sterling
Calder	Hale	Oddie	Sutherland
Cameron	Jones, N. Mex.	Pepper	Wadsworth
Colt	Lodge	Phipps	Warren
Cummins	McCormick	Ransdell	Watson, Ind.
Curtis	McCumber	Rawson	
du Pont	McLean	Reed, Pa.	

NAYS—23.

Ashurst	Kellogg	Pomerene	Smoot
Capper	Keyes	Reed, Mo.	Stanley
Dial	Lenroot	Robinson	Trammell
Fletcher	Moses	Shields	Underwood
Harrison	Newberry	Simmons	Walsh, Mont.
Heflin	Overman	Smith	

NOT VOTING (PAIRED)—24.

For

Dillingham	Jones, Wash.	New	Townsend
Elkins	Ladd	Poindexter	Weller
Frelinghuysen	McKinley	Spencer	Willis

Against

Caraway	Glass	King	Owen
Culberson	Harris	LaFollette	Swanson
Gerry	Hitchcock	McKellar	Williams

NOT VOTING—11.

Borah	Johnson	Norris	Walsh, Mass.
Fernald	Kendrick	Page	Watson, Ga.
Harreld	Nelson	Pittman	

So Mr. BURSUM'S amendment was agreed to.

Mr. MOSES. I wish to give notice that I shall reserve a separate vote on this amendment in the Senate.

* * *

(August 18, 1922)

Mr. MOSES. Mr. President, when this action was taken in the Committee of the Whole last night I reserved a separate vote on the amendment in the Senate. The Senate, however, by such a decisive majority decided in favor of the rates contained in the amendment offered by the Senator from New Mexico that I have no desire to detain the Senate and waste its time, in view of the limited number of hours at our disposal. I therefore shall not press the right to a separate vote which I asked for last night.

Mr. LODGE. Mr. President, for information, the amendment read by the Secretary——

Mr. SIMMONS. Mr. President, there is so much confusion in the Chamber that I can not hear a word the Senator is saying.

Mr. LODGE. I will try to make the Senator hear.

Mr. SIMMONS. I know the Senator is trying to make me hear, but the Senate will not permit me to hear.

Mr. LODGE. They do not permit it, but I will try to penetrate the noise if I can. I asked whether the amendment offered by the Senator from New Mexico last night and adopted by a decisive majority in regard to the duty on dyes is not practically the same as the one which has just been read as a reservation?

Mr. MOSES. It is the one.

Mr. LODGE. That is what I supposed. Then why should we waste our time over it now?

The PRESIDENT pro tempore. It was reserved for a separate vote, and it must be voted on at this time.

Mr. LODGE. I understand.

Mr. SMOOT. Mr. President, I do not believe Senators know in detail what their vote meant yesterday. If this amendment is adopted it means that every dye and chemical the product of coal tar coming into this country shall pay 90 per cent ad valorem and 10½ cents per pound specific. Do Senators realize what burden they are placing upon the users of these dyes and chemicals?

Mr. BURSUM. Mr. President, I know the Senator does not desire to mislead us in this matter, but on the dyes which are not manufactured here and which we are obliged to bring in from the outside the foreign valuation applies, so that the duty is less, of course.

Mr. SMOOT. Mr. President, the duty is not less. The duty is only less as far as the transfer from the American to the foreign valuation is concerned, but the duty is still 90 per cent ad valorem and 10½ cents a pound.

Mr. BURSUM. But 90 per cent on the American and 90 per cent on the foreign valuation are entirely different propositions.

Mr. SMOOT. It is an embargo a thousand times over, and worse than an embargo.

This means that every coal-tar product which is not made in the United States will bear a rate of duty of 90 per cent ad valorem and 10½ cents per pound. In other words, in most of the cases of goods coming into this country they would have to pay a rate of duty so high that it is a crime to impose it.

Mr. FRELINGHUYSEN. Will the Senator support an embargo, if this provision is defeated?

Mr. SMOOT. I say that I would rather a thousand times have an embargo than this provision, and so would the Senator from New Jersey. If the Senator from New Jersey will tell the Senate what he really believes, he will say that he would rather have the embargo than this provision; and he wants to protect this industry, and so do I. But this means that no matter whether a similar product is made in this country or not, there is to be a duty of 90 per cent on importations and 10½ cents specific. If the item costs 10½ cents a pound, then the specific duty is 100 per cent, and the ad valorem duty is 90 per cent besides. Why load the American user with that kind of a burden?

Mr. SIMMONS. Mr. President, will the Senator yield?

Mr. SMOOT. I have only a few moments.

Mr. SIMMONS. I just want to ask a question. What will be the aggregate increase over the duties in the bill if we raise the rate to 90 per cent ad valorem and $10\frac{1}{2}$ cents specific, and then adopt the American valuation?

Mr. SMOOT. Of course, if we adopt American valuation, none of the articles can come into this country, even if they are given away, without paying to the importer a certain amount of money. In answer to the other question of the Senator, I will say that it is a 50 per cent raise over and above the rates put in the bill, which I supported.

Mr. SIMMONS. Changing from the American to the foreign valuation would probably double the rate, or more than double it?

Mr. SMOOT. It would more than double it as to these items. I want to say to the Senator from New Jersey that rather than have this outrageous thing put into law I would prefer to vote for the limited embargo. I will say further to the Senator from New Jersey that no human being can defend this before the American people. It is impossible of successful defense.

Mr. McCUMBER. Mr. President, the embargo provision was defeated by a vote in the Committee of the Whole some time ago. The Committee on Finance reported in favor of an embargo. I agree entirely with the Senator from Utah that this will be a complete embargo. That is why I shall vote for it.

Mr. FRELINGHUYSEN. Mr. President, I offered the amendment to the bill providing for an embargo of one year, with a further provision allowing the President, if it was necessary, to extend it for another year. That was defeated in the Committee of the Whole.

I had an amendment prepared to offer in the Senate. I am not convinced that the Senate is willing to vote for an embargo. I believe that this industry needs all of the protection which can be given in this bill, and therefore I am in favor of the rates imposed in the Bursum amendment, because I want to see the industry preserved in this country. I am willing to take my chances that some of these rates are too high, and stand for a readjustment under the presidential power; but my primary interest in this amendment is that it protects the industry beyond the original provision for rates in this bill.

When you realize that England has provided a subsidy of $50,000,000 to encourage an independent dye industry, and embargoes against other countries; when you realize that Italy has an embargo; that Japan guarantees 8 per cent return and profit to every dye industry established within her country; when you realize that France has an embargo, you must understand that it is necessary for us to adopt drastic provisions to protect this industry, which has grown from an investment of $3,000,000 capital, when the war broke out, to $174,000,000 capital; and that, apart from this, the chemical industry in this country has expanded until to-day it represents an investment of $2,500,-000,000.

Germany dominated the dye industry prior to the war. The question now is whether we shall protect this industry and make

it independent in this country. There are in my State 55 plants; and I am not referring to the Du Ponts, or the Allied Chemical Corporation. There are 55 individual plants, with capital from $1,000 to $1,000,000, which have been built up under this embargo. They are manufacturers who, when called upon by the textile interests of the country to furnish dyes, conducted experiments and furnished dyes to the American textile industry, and kept the workers employed during the war.

There is a higher motive in my desire to have the protective duties in this amendment adopted, and that is the question of national defense. When we realize that it was due to the genius of the German chemists, and the advance in the science by the German industries, that enabled Germany to get almost to the channel ports; when we realize that the next war will be fought with chemicals, I think it is our patriotic duty to give this industry the highest protection that can be imposed. Therefore, that is why I am for this amendment, realizing that there are not enough votes in this Chamber to pass the embargo provision, although I would have preferred that policy to this.

Mr. BURSUM. Mr. President, it is idle to debate whether or not the rates are based upon equity, and whether or not they are exactly just. Everyone knows that with a multitude of rates and thousands of dyes, it would be impossible for Congress to definitely fix the multitude of rates which would be required to cover this industry. Even the Tariff Commission, our scientific agency, do not feel equipped at this time to provide these rates within any very short period.

There is no hazard to be risked by the enactment of this amendment, so far as the country is concerned.

We can trust the President and our Tariff Commission to frame a just and equitable rate at the earliest possible opportunity, and in the meantime the amendment simply tides this great industry over until those rates can be promulgated by the President under and by virtue of section 315.

No nation can be considered as a leading nation among the nations of the world unless it can establish within its borders superiority in chemistry, and that applies not only to national defense but to the development of every industry. It applies to the development of our farms, and to nearly every other line of business.

It has not been long since we sent to the other side of the seas 2,000,000 Americans to suppress the ambition of Germany to set up an autocracy of the world. American blood was shed on foreign soil to save the world, and if we are to allow this industry now to perish, that shedding of blood will have been in vain. We will have set aside what was obtained through the great World War. We will have put America at the mercy of the Germans again.

I say that when Mr. du Pont wrote the Senator from Utah that he favored the manufacture of all dyes in this country he was right, and I am in favor of Americans making these dyes. There is no reason why they should not make them as well as the manufacturers in any other country on the face of the earth, and if we make these dyes we will have the money at home and we will have the dyes. We will have them available for the

country's defense, and the country can compete with any nation on the earth.

I think the amendment ought to be concurred in.

Mr. EDGE. Mr. President, in connection with the consideration of this subject there appeared in Washington yesterday a delegation of 50 or more young men who have been engaged and are engaged as working chemists in some of the plants throughout the country. They prepared what appeals to me as a very interesting statement of their interest in this matter, and as it is short, I would like to have the Secretary read it in my time.

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WASHINGTON, D. C., *August 16, 1922.*

To the President and Members of the Congress:

We are chemists employed in the research, operating, and analytical departments of manufactories of drugs, dyestuffs, and other organic chemicals. We want you to know what will be the position of America's chemists of to-day and the future if this industry is permitted again to fall under German control.

The events of the past two weeks have suddenly made clear to us the danger to us and our science. The omission of the selective embargo from the pending tariff will mean the permanent loss of the organic chemical industry to America.

We approach this matter as chemists do, from a scientific and humanitarian standpoint, in a simply logical fashion. We want to present the chemists' point of view. We believe that this has not yet been done effectively.

We have spent from four to six years in collegiate courses specializing in some branch of chemistry, a highly technical subject. The last few years we have devoted whole-heartedly to the advancement of America's knowledge and ability in organic chemistry. Failure to include in the tariff bill the one positive guarantee of our continued existence will sweep into oblivion our time, our positions, and, above all, our special training.

Already the results are apparent in this industry. No man among us to-day can advise his younger brothers to take up this work with any hope of reward—indeed, he would even have no hope for a job. We ourselves cannot see ahead opportunities for making a living.

Already research work, which can be accomplished by trained chemists alone, has been discontinued, even abandoned. But few will endow research for its own sake, and the work accomplished under such auspices, excellent though it may be, must be far less than our important position in the world demands.

Plainly, the industry which we had hoped to make our life work faces financial disaster. Daily additional firms are overtaken by it. There is no one to whom the trained chemists thus abandoned by the wayside can turn to use their special abilities and knowledge. The remaining firms are overburdened now.

New and enlarged facilities and instructing staffs recently provided in many of our educational institutions call for still more new students. They will not come under present circumstances. More than $40,000,000 are now invested in buildings and equipment devoted to chemical instruction and research in the colleges and universities throughout the country. Recent investments in chemical educational facilities include: New York, $6,700,015; Massachusetts, $4,146,017; Ohio, $3,196,204; Connecticut, $3,786,495; Pennsylvania, $2,444,521; Minnesota, $2,351,210; Illinois, $1,886,983; California, $1,390,587; Michigan, $1,390,850, and Indiana, $1,098,726. Shall these facilities be scrapped and the instructors sent out into the already overcrowded field? They must be unless we retain our organic chemical victory so hard fought for and dearly won.

The world to-day depends on the chemist for its advancement. Who is to replace gasoline and create new lubricants? Who has replaced the silkworm? Who is to lead in eliminating present manufacturing waste? The chemist. There is no industry where his works cannot be seen. Is this industry which is a training school in knowledge and technique—this industry which is peculiarly the chemist's own to be discontinued by lack of knowledge, by inattention, or, we hesitate to think, by neglect?

Transcending the chemist's own welfare, however, is the future of all the people of our country beside which that of the chemist is negligible. Dyes we could live without, but those new therapeutics of recent years have become indispensable. Without this industry, whence will come those sinews of defense which we were so slow in producing in the war should the time again come when they must be had to preserve our personal and national lives? The knowledge which will enable us to maintain a position of equality can be gained only through constant research.

America must not abandon this industry. We must continue to increase our power. The administration has assured us that we shall be permitted to live, and this we entreat—yes, demand—shall be kept for the welfare of our fellow citizens, for ourselves, and for American posterity.

COMMITTEE OF AMERICAN CHEMISTS,
A. J. PASTENE, *Chairman.*

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Mr. SIMMONS. Mr. President, as I discussed this matter last night, I do not desire to discuss it at length again. The Senator from Utah [Mr. SMOOT], who is familiar with it, has advised us that the placing of these rates upon the American valuation instead of upon the foreign valuation, upon which all other rates in the bill are based, would increase the rates of the bill, at least 100 per cent, as I understood, and I think that is a correct statement on the part of the Senator from Utah.

The rates in the present bill, to which the Senate has heretofore agreed, are 50 per cent ad valorem and 7 cents a pound. The amendment we are now considering would increase that ad valorem from 50 to 90 per cent and the specific rate from 7 to 10 cents. That would be undoubtedly an increase in the rate to the extent of certainly not less than 50 per cent. A 90 per cent duty upon the foreign valuation basis would be 180 per cent duty upon the American valuation. So the effect of the amendment is practically to impose an ad valorem rate of 180 per cent, plus a specific rate of 10 cents a pound, upon the various dye products mentioned in the paragraph.

There are two objections to this amendment, Mr. President: First is the fundamental objection that, having imposed the foreign valuation throughout the bill, we now propose with reference to this particular item to substitute the American valuation, a principle which the Finance Committee itself has overwhelmingly condemned as unsound and a proposition which, if it were to be applied to the general items in the bill, would be overwhelmingly voted down by the Senate. It is proposed to establish that principle and write it into the bill with reference to the enormous quantity products which are the result of the operation of the dye industry in this country. I object to it for that reason.

I object to it also, Mr. President, upon the ground that we have repudiated the idea of an embargo upon dyestuffs. That was discussed thoroughly in the Senate in Committee of the Whole and was voted down. The embargo which we voted down was only a limited embargo and was to expire at the end of one year, with the privilege of renewing it only for an additional year. Its possible life was only two years, but we voted it down. Now, here we have revived the principle of an embargo, for these duties admittedly are an embargo. No man can question the fact that 150 per cent ad valorem plus 10 cents a pound on dyestuffs would be an embargo in effect. Now, we have revived the principle of the embargo and it is not limited in the amendment to two years, but on the contrary once the amendment is written into the law

it would become a permanent law of the United States until repealed.

I want to say to Senators on this side of the Chamber that we have voted against the American valuation principle or announced ourselves against it. We have voted against an embargo. Shall we now stultify ourselves by voting not only for an embargo but voting for the American valuation and voting in effect for a permanent embargo in favor of an industry which we have already favored more than any other industry ever was favored before? When we first began to raise the duties upon these articles at the request of the manufacturers they told us that the raise was all they required in order to enable them to meet German competition, and that was before we went into the war.

Mr. UNDERWOOD. If the debate is concluded, I ask for the yeas and nays.

The result was announced—yeas 39, nays 31, as follows:

YEAS—39.

Ball	du Pont	McCumber	Reed, Pa.
Brandegee	Edge	McLean	Sheppard
Broussard	Ernst	McNary	Shortridge
Bursum	France	New	Stanfield
Calder	Frelinghuysen	Norbeck	Sterling
Cameron	Gooding	Oddie	Sutherland
Colt	Hale	Pepper	Wadsworth
Cummins	Jones, N. Mex.	Phipps	Warren
Curtis	Jones, Wash.	Ransdell	Watson, Ind.
Dillingham	Lodge	Rawson	

NAYS—31.

Ashurst	Harrison	Moses	Smoot
Borah	Heflin	Newberry	Stanley
Capper	Hitchcock	Overman	Swanson
Dial	Kellogg	Pomerene	Trammell
Fletcher	Kendrick	Robinson	Underwood
Gerry	Keyes	Shields	Walsh, Mont.
Glass	Lenroot	Simmons	Watson, Ga.
Harreld	McKellar	Smith	

NOT VOTING (PAIRED)—18.

For

Elkins	Nicholson	Spencer	Weller
Ladd	Poindexter	Townsend	Willis
McKinley			

Against

Caraway	King	Nelson	Pittman
Harris	La Follette	Owen	Williams
Johnson			

NOT VOTING—8.

Fernald	Myers	Culberson	Reed, Mo.
McCormick	Page	Norris	Walsh, Mass.

So the amendment was concurred in.

PROGRESS OF CHEMISTRY

Address
Delivered Before
The American Chemical
Society

By

Edgar F. Smith

SEPTEMBER NINTH, NINETEEN TWENTY-ONE

Progress of Chemistry

Address delivered before the American Chemical Society, September 9, 1921

"SINCE chemistry has become regularly and philosophically progressive" are the words of my text, snatched, as it were, from an opening paragraph of that little but genuine classic—*Chemical Affinity*, developed and elaborated by Claude L. Berthollet, and appearing in its American dress in the City of Baltimore, in the year 1809.

Circulated thus early in our country's history, among the fathers, seems conclusive that more than a century ago—yes, more than a century and a half ago—there were among the inhabitants of the Union, those whose tastes and thoughts turned to the philosophy of our science.

Pause a moment. In 1809, Priestley was no longer with us. He and others who had given inspiration and impetus to a host of young Americans to press forward in chemistry, had laid aside their duties and cares, and had gone

To Explore the Shadow and the Dust.

Yes, forever, must Joseph Priestley be regarded as the particular one who aroused and compelled early Americans to pioneer efforts in the theory and practice of chemistry, though he himself had become

Lost in the Dark Wood of Error.

The awakening, in the seventeen-nineties, is observable, among other things, in the text-books written by native Americans; in the crude but intensely earnest

and significant efforts in research, and in the numerous applications of the principles of chemistry to the founding of industries calculated to uncover and utilize the resources of the country. As there was continuous anxiety in regard to the country's protection, constant search was made for the constituents of what was then held to be the greatest explosive—gunpowder. Its components were sought everywhere throughout the land. The pioneer chemical society of the world—The Chemical Society of Philadelphia (1792)—was tireless in assembling and disseminating information relative to the manufacturing of nitre. What knowledge it acquired was promptly and freely given, while "the printers of newspapers throughout the United States are requested to publish" what the Society submitted. Chemists then, as chemists in 1914 to 1918, hearkened and addressed themselves at once to the call of their country in the hour of peril. Men of war, men of trade, men of every profession and station, turned then, as in very modern times, to the humble chemist—and right well and enthusiastically did he respond. The results of the seventeen-nineties compared in no wise with the marvelous results obtained by the chemists of the twentieth century, but of spirit the fathers could well boast, for it was that spirit, without question, which made possible the wonders of these later years.

Down through the intervening decades the "progressive" character of the science grew, and with it the patriotic spirit. Love of country—desire that it might become important and powerful, was clearly shown even before the closing years of the eighteenth century by the alchemists of this western world,

according to the researches of Dr. C. A. Browne, who has submitted the most irrefutable proof of the existence of primitive chemical industries in the old Bay State, and in several of the parishes of the Old Dominion to the South; so that in the infancy of the Republic there were things chemical, upon which the devotees of the science could build, and that they actually did build; and at the close of the eighteenth century and in the beginning of the nineteenth century were inspired so to do may be corroborated by many examples.

But not all the thoughts of the fathers were on warfare bent, as the gunpowder incident would suggest.

What a glorious moment it was in the history of chemistry in America when young James Woodhouse, by original experiments, made in his laboratory, with Priestley present as a deeply interested spectator, laid low the idea of phlogiston and demonstrated the true constitution of water! It was, again, an example of the "philosophically progressive" spirit of chemistry here in America, "the greatest birth of time!"

An additional advance in pure science and in its application, was the disclosure of the oxyhydrogen flame with its concomitant—the platinum industry, which early sprung up in Pennsylvania. Consider for a moment that oxyhydrogen flame! It gave our fathers in chemistry a degree of heat beyond anything previously known to them. The present world was astounded at the high temperature of the electric furnace, but what must chemists of 1801 have thought of the oxyhydrogen flame which caused gold and silver to melt and run like water; and this flame, as time passed, was transformed into the oxyacetylene flame, which has held us in breathless silence on beholding

its applications—yet, it was only further proof that "chemistry has become regularly and philosophically progressive."

Industries, of many varieties, came into being, such as an aqua fortis factory, a sal-ammoniac factory and a factory for Glauber's salt, all supplying the whole Union with their particular products in the year 1797. And a learned society in the same year offered a substantial prize for an essay on *American Permanent Dyes!* How long has it been necessary to wait to realize this early demand? We have American permanent dyes it is true, but are they to be taken from us by those of our own family? Would the spirit—the American spirit—of the fathers of the Republic and the pioneers of chemistry have countenanced such an act? Has that spirit become dormant, or, perhaps, infected with a microbe, which, permitted to travel its course, will surely lay low and utterly annihilate that which should be the pride of Americans in this very hour!

The manufacture of oil of vitriol was early begun and conducted with unprecedented success. Its concentration was accomplished in vessels of platinum, a fact worthy of note. Muriatic acid, soda ash, tin salts, chrome yellow, white lead and many other true chemical products were brought into the market,—evidence all of the "philosophically progressive spirit" of our science and its cultivators in the young republic which, again, in 1812, became involved in a second struggle with the Mother Country; "but we need not stir the embers of that fire," except to remark that the havoc and loss created by the unpleasantness led many foreigners, versed in chemical manufacture and

lore, to settle among us; and there followed factories for Prussian blue, Scheele's green, and numerous other pigments. Under the control of these newcomers, began industries which since have acquired world renown, notably that of Powers-Weightman-Rosengarten—now one of the largest establishments of the world.

The spirit of the early chemists affected all who came in touch with them. Their enthusiasm and loyalty were contagious, and it is most refreshing and soul-filling to read from a letter of John Adams, second President of the United States, to John Gorham, pastmaster in the art of writing chemical text-books, away back in the long-ago, when he was about to assume the newly established Erving Chair of Chemistry in Harvard, in 1816. Mr. Adams wrote:

> I rejoice that such a Professorship is established . . . I am afraid to express my wild ideas on this subject. We are all Chymists from our Cradles. All mankind are Chymists from their Cradles to their graves . . . The material universe is a chymical Experiment . . . Can you Chymists discover any possible or conceivable connection between Sensation and Reflection and Matter and Motion? Modern philosophers say Spirit is a word void of sense. I say matter is a word void of sense . . . When and how shall we discover the smallest Particles of Matter in the Universe? When and how shall we discover the original causes of the mysterious diversity of odours and flavours; consider the odour of the Apple, the Quince, the Lime, the Lemon, the Orange, the Strawberry, the Raspberry, the Thimbleberry, the Pine Apple, the Grape, the Pennyroyal, the Saffron, the Balm, the Sage, the Mint, the Tansy, the Cresses, the Sorrels, the Mallows, the Roses, the Blossoms, the Lillies, etc., etc., etc. . . . What are they? What shall we say of Heat and Light? Wave the former for the present, and think of the latter. A Spermaceti candle placed on a steeple on the great Blue Hill would be seen two miles, at least. A small portion of the Sperma Ceti, therefore, converted into light, must fill a sphere of four miles diameter,

> with matter, if light is matter, and so full, that the human optick nerve can discern it in every part of that sphere. How attenuated must that matter be? . . .
>
> Chymists! pursue your experiments with indefatigable ardour and perseverance. Give us the best possible Bread, Butter, and Cheese, Wine, Beer and Cider, Houses, Ships and Steamboats, Gardens, Orchards, Fields, not to mention Clothiers or Cooks. If your investigations lead accidently to any deep discovery, rejoice and cry Eureka! But never institute any Experiment with a view or a hope of discovering the first and smallest particles of Matter. . . . I pray you consider this letter as confidential. If it should get abroad I should be thought a candidate for the new Hospital before it will be ready to receive!

Would that the distinguished ex-President of the United States were with us today.

The fathers felt it was their duty to publish and disseminate the knowledge they were acquiring through their investigations. They did not seek to hide their discoveries. They believed in publicity. Probably because they desired that their science might receive honor but also that their Country might be assisted in winning its way among the nations looking down upon it. And there were many well-trained, thoroughly qualified men who conducted courses of lectures with a view of making the nearness of chemistry patent to every individual. They were the forerunners of present day University Extension lecturers. One of these heralds of the "coming science" said:

> No science is so intimately connected with the pursuits of man . . .as chemistry. . . . It embraces the whole range of created nature. In its researches it comprehends all substances, animate or inanimate; it explores their elementary principles, it unfolds their combinations, it traces their affinities, it ascertains the result of new associations, new combinations. In every employment we feel its influence or want its aid.

Thus spoke a propagandist, who knew how to make his science "come home to every man's business

and bosom." His example might be worthily followed.

True, the world does discuss chemistry quite a bit since the great war, and prognostications as to the part it will play in future wars are heard on every side. But chemistry loves peace, and the course pursued by the fathers should be closely scanned. In the words of that brilliant patriot, Fisher Ames:

By looking into history and seeing what has been, we know what will be.

The enlightenment of the general American public relative to our science as it was established by American chemists will contribute to a spirit of solidarity. The fact that American men of chemistry can do all that chemists elsewhere can do, is bound to engender a respect for home endeavor and products. None should fail in making clear the "philosophically progressive" steps of chemistry in this dear land.

Even in the closing years of the eighteenth century those who cherished research in the science found channels through which their discoveries could reach the light. The *Medical Repository*, founded by that profound scholar, diplomat and chemist, Samuel L. Mitchill of Columbia, devoted its pages largely to the sciences. Precious are the moments one may enjoy in quietly searching its pages for chemical information. It is there—real research; at times quite crudely presented but rich in fruit. One feels like hugging those pages on which are laid bare, in splendid English, the manly, independent conquests of the fathers; and, there was also the *Medical Museum*, in which appeared an abundance of chemical material. If assembled by itself it would make a most impressive volume. These

journals presented the beginnings. With them must be included the *Memoirs of the Columbian Chemical Society*, Volume I, which appeared in 1813. It is exceedingly rare. Its contents are original, partly speculative and partly practical. They display the earnestness of the chemists of that day, in the prosecution of their science.

Careful and sympathetic consideration of the contributions contained in the *Medical Repository*, the *Medical Museum*, and the *Memoirs*, indicates that chemistry has been "regularly and philosophically progressive" in this country, where it was ushered in at a rather late day, considering its history in Europe.

The study of text-books, chemical technologies and hand-books of chemistry, issued from 1750 to 1850, will fully confirm the "progressive" spirit of our science for at least a century. One is wonderfully repaid by the study of this literature. The educationist will find in it a rich field for exploitation. The gradual evolution of system in arrangement of subject-matter, the tardy adoption of budding theoretical ideas, indicative of a conservative and judicial attitude, are strikingly illuminating. Through it all there is discernible a very discriminating judgment.

Analysis of such printed documents breeds high respect for those who led the van in the dissemination of chemical knowledge. There are, of course, in the lists many volumes of foreign origin, but independence of thought on the part of the American editors is seen in the many additions and emendations which have come from clear thinkers. And, the strictly American productions are not imitations. They are free and independent expressions—fresh, modern and vigorous

in conception and nature. Every student of chemistry in this country will come from their study with an uplift and encouragement which can only enhance the value of his own literary efforts, and instil a greater spirit of patriotism.

Naturally, the earliest literary chemical essays to enter this country were English and Scotch in origin. A few came from French soil, rendered into sturdy English and edited with freedom and precision. It is barely possible that the Scotch imprint was made first and that the teachings of Joseph Black spread far and wide because the first chair of chemistry in America was filled by a favorite pupil, who gloried in proclaiming the ideas and achievements of his honored master.

The German influence, in the literary and experimental way, on American chemistry did not appear until after 1814—after some of the ablest younger American scholars, in the domains of history, philosophy, the humanities and mathematics, had returned home and unconsciously moved their associates, fond of the sciences, to explore the fields of German endeavor in these directions. How dominating this influence became on American study, research and manufacture requires no comment. It actually blinded us as to the advance of other peoples and lands in the science we love, and caused us to despise almost our own undertakings. But, it was "regularly and philosophically progressive," otherwise it would have lacked a German characteristic—which characteristic, fortunately, belongs to the chemistry of every clime. It is innate in the science—asserting itself wherever opportunity offers.

But these old volumes—examine them for yourselves. Let them not be

A Fountain Shut Up—A Book Sealed.

And as to early research—could there be anything more indicative of the "progressive" character of American chemistry than the isolation of potassium from its carbonate by heating the latter with lamp-black? This was done in 1808. That it was a fundamental experiment everyone will admit. Again, what shall be said relative to the construction of an electric furnace in 1820 in which carbide, graphite and metallic calcium were produced? And here, in our home country, this was accomplished. Then mercury, also, was employed as cathode in the electrolysis of metallic salt solutions. These were epoch-making discoveries. They antedated everything of similar nature done subsequently. All this was the work of a far out-post—who in a large measure was a forerunner of applied physical chemistry—one of those "swift runners who hand over the lamp of life," and transmit from one generation to another the fire kindled, in the childhood of the world, at the Promethean altar of science. But, alas! it was his lot to pass on and his discoveries remained unknown, unheralded, untaught until a later generation re-discovered them. They were "progressive," but there was no one to understand, avail and apply them! Next followed, in 1830, that now classic method of producing chloroform—heating alcohol with bleaching lime. This antedated Souberain, Dumas and Liebig—another magnificent example of what might well be expected from a "philosophically progressive" science! The world has sought to wrest this dicovery from its rightful originator—but it is ours?

In matters theoretical, the fathers were also in the forefront. From Berzelius was wrung the concession

that bodies defined by him as "double salts" were in reality salts of definite acids of higher order as substantially demonstrated by the most modern research. And in the early years of organic investigation, it was T. Sterry Hunt who actually set forth the doctrine of types.

Many of us grew up ignorant of these great achievements in our own land, or if we knew them forgot that, as in the days of the fathers so ever since, chemistry has been "regularly and philosophically progressive."

The burden of my desire is that the youth of the land, entering our science, shall be broadly and fundamentally trained in its principles and in its achievements. That, while they may glory in their own particular successes, mental and material, they shall constantly say to themselves—what have we done for our country? Until the time comes that they may have the happiness of thinking that they have contributed in some way to the progress and to the good of humanity. They should in all sincerity believe that

> *Chemistry is most honourably, when she is most usefully employed; and is equally in her own proper element when analyzing the diamond with Davy, and when descending, with humble industry, to the assistance of the manufacturer at his loom, or the dyer over his vat.*

My desire would have no East, West, North or South in chemistry, but one united body from all sections eager to carry the science into every walk of life—even into the halls of government that their occupants may understand how intimately chemistry is interwoven with the laws and welfare of the land. If America is to continue among the nations in the place she has won, that science which confessedly makes wealth, and guards and preserves the fireside, must see the industries

erected by it, supported by every kind of just legislation; selfish interests *must* give place to the country's best interests, that in the end it is America and her future which must be respected.

That old but ever new document—the Constitution of the United States—bids its people heed this word, but there are those who have discovered a new charter of human liberty and they invite us to take it as our guide and sail unknown seas, uttering invocations in its name. These are of those who forget what chemistry has done for America and will continue to do in extending her importance among the kingdoms of the earth and in maintaining that peace we all so ardently pray may be ours, that the science of our heart's choice may flourish and shower blessings on our people.

To our foreign guests—no, not foreign, but brothers from distant lands—let it be said your presence does us great honor and we are supremely happy to have you with us. The words to which you have listened are, of course, primarily intended for the members of the American Chemical Society, whom we long to knit into one great enthusiastic body, spending itself, among other things, in the interests of our common country; so, occasionally, we feel called upon to advise and affectionately admonish them of the "rock from whence they were hewed and the hole of the pit from which they were digged."

But do we all not need ideals—lofty ideals, lifting us up and beyond the purely sordid things which so easily beset us? Was not this aspiration heroically demonstrated in the recent world struggle when lads representing every nation in this auditorium hurled

themselves against a common foe? And to those who called their act sublime, and to those who decried it in knowing tone, they hurled back the answer

Here, while the mad guns curse overhead,
And tired men sigh, with mud for couch and floor,
Know that we fools, now with the foolish dead,
Died not for flag, nor King, nor Emperor;
But for a dream, born in a herdsman's shed.

Men of Chemistry from every land—what is your dream?

By way of conclusion,—to the friends from the Dominion to the North and to those who journeyed from beyond the sea; to all, no matter what your native tongue, the following story expresses our feeling for you:

Late in the afternoon of Decoration Day, when the shadows were growing long, a pilgrim stood in Monument Street in Concord, Mass., and witnessed the closing scenes of a day of memories. Over the hill in Sleepy Hollow the military had fired their last salute to the Grand Army of the Past. The air was laden with the fragrance of the woods and the meadow. Down the lane which leads to Concord Bridge where the shot was fired that "was heard round the world" only a few lingered. The long row of maples that form the border of the lane were nodding lazily in a gentle breeze, and their deep shade beckoned a welcome. The mysterious creatures in the hollow that make the chorus of the night were beginning their requiem. The crowds of townspeople out in main thoroughfare were streaming back to the town center, back to the reflection that all the brave had been remembered that day—back to their duties, their joys and their sorrows.

The pilgrim stood under the shade of the maples before the tablet that nestles between two great trees over the place marking the spot where the first two British soldiers who fell in the war for independence lie sleeping. The tablet bore the legend, "They came 3,000 miles and died to keep the past upon its throne." No names appear upon the stone.

Somebody, some soul touched with compassion and filled with poetry, had placed upon the spot at the foot of the tablet a rude bouquet of wayside spring beauties and wild

flox tied with a tangled piece of twine picked up in the path. That was all. A few of God's thoughts gathered along the way where the race of men pass by brooded over the place that has been dedicated to the unknown.

Through little spaces between the leaves of the maple over the stone of the soldier dead "The Old Manse" darkening in the shade of its guardian pines, stood out. The pilgrim pondered whether some spirit akin to that of the former tenant of the "Manse" to whom the wayside flowers, the trees, the rocks, the brook and all the denizens of the forest talked knowingly and sympathetically, had moved the fingers that placed this vagrant bouquet on the ground where the first redcoats fell.

No. A shaft of sunlight stole through the leaves of the maple overhead and played with the dust-covered bunch of wayside flowers. They became radiant with glory, and the tangled piece of string that bound them took on a golden hue. God's smile was in the sunbeam and it was the breath of his angels that kissed the cheek of the beholder as they seemed to whisper—"Brethren."

OUR SCIENCE

Address
Delivered Before
The American Chemical
Society

By
Edgar F. Smith

SEPTEMBER SIXTH, NINETEEN TWENTY-TWO

Our Science

IN considering the history of chemistry, not so much from the points of activity of an individual or individuals, but rather with a view of ascertaining the line of development of the science, certain facts impress themselves upon the inquirer. To illustrate this thought, the rise and development of the science in America may be briefly noted.

Among the earliest settlers in Virginia and in the Bay State were artisans and men of attainments higher than the ordinary. They knew that the mother country expected them to search for objects of value. Hence, efforts, in a crude way, were made to transform ores into metals, and to extract from plants coloring materials which, perhaps, might be applied in useful ways in the hands of persons possessing better means for their study.

Trials of this sort were made in the early part of the 17th Century. True, they were sporadic, and while promising good results these did not justify development on a very large scale, for the object of the researchers was plainly *utility*.

In time, with the advent of more men of the medical profession in the settlements, which began to line the Atlantic Coast, there came a strong desire to overcome the physical ailments of the human body. As ages and ages before, the Pierian Spring had inspired men to follow the Muses, bringing them joy and happiness, so men of later generations intuitively turned to natural springs, hoping there to find a panacea for all the ills that afflicted humanity. Hence, in the earliest printed literature of this country, one discovers abundant references to the medicinal qualities of the springs

of the land. The medical men of that period, with such knowledge of chemistry as they possessed, carried out numerous crude analyses of mineral waters. The latter were discussed, their benign properties emphasized, long before the people thought of separating themselves from the mother country. Although the chemical studies of these springs, believed to possess medicinal virtue, were extremely primitive, yet they give a pretty fair picture of the state of chemical analysis in the early part of the 18th Century. While the promoters of this field of chemistry were, at heart, medical men, seeking to alleviate the ills of the flesh, they firmly believed that the hundreds of springs containing chemical principles, were endowed with a curative virtue; but observe—that chemistry for itself was not the object of their thought. Chemistry was only the handmaid of medicine, so that this second effort, in which chemistry was emphasized to such a high degree, may be stamped *self-preservation.*

The direction in which our science moved, suddenly changed when the inhabitants of the Colonies began to feel able to maintain themselves, to grow and become a power in civilization. Then chemistry was appealed to with the anxious inquiry as to how it could aid in furthering war—so imminent. The great explosive of the middle 18th Century was gunpowder. In the Proceedings of Continental Congress for 1775, one may find a broadside by Dr. Benjamin Rush, with reference to the European methods of producing nitre, and with suggestions as to how that important ingredient of the great explosive might be prepared in large quantities here at home. This broadside, never referred to later, was a document of highest value to chemistry. It had been prepared by one who had studied under the cele-

brated Joseph Black, and who, although a physician—a practitioner of medicine—was yet so thoroughly imbued with the many-sidedness of chemistry that he was willing to become the occupant of the first independent chair of chemistry in the Colonies, insisting again and again that chemistry was a science of extraordinary importance. He it was who, despite his activity as a physician, incited those having chemical knowledge to devote themselves to the preparation of nitre and the other two important ingredients of gunpowder.

Thus, our science aroused and stirred men to activity in the interest of *protection* and *independence*. Our forefathers helped give to the world this new and glorious Republic. One must not forget that with the men—the soldiers, the sailors, with all who participated in the great struggle—the followers of chemistry were accorded a high place in the lists of those who made it possible for the members of Continental Congress to rock the cradle of the infant Empire.

Turn back for a moment. The motive of chemistry in this country was first, *utilitarian;* second, *self-preservation;* third, *protection* and collaterally the development of *independence* of the people, and this independence, acquired largely through the efforts of chemistry, was maintained and made forever secure by similar activities in the War of 1812.

But after the inauguration of these beginnings the student observes that here at home emphasis is constantly placed upon benefits to be derived from the exploitation of industries. The natural resources of the country were sought out by chemists. They frankly confess it. In a chemical study of these natural resources, they hoped to discover everything which

might contribute in the least to the comfort, the welfare and happiness of the people of the new Republic. This desire was most praiseworthy. For, here we were, a young people, with an immense domain reaching out from centers, established along the Eastern Coast of the country, conscious that sooner or later, men would pioneer into those greater, unexplored territories beyond, and that from them would be brought treasures of immense value, and therefore there should be in the older portions of the States, places where the newly discovered materials might be examined, studied and applied. The earliest chemists were also genuine pioneers. The spirit of the pioneer lived in them. The consciousness of the sacrifices made in order that the Colonies might be developed into the young Republic engendered an intense love of country in them, so that their work in exploitation of the vast and unexplored regions about them was strongly impregnated with the love of country, with the idea of making it a land which would be sought and respected by people from every quarter of the inhabited globe.

As an example of the utilization of products, brought from the newer country, let one instance engage our thought. It was the discussion in regard to the ores of zinc, which had been uncovered at Phoenixville, Pa. One of the participants in this controversy was the distinguished Adam Seybert, and the other the renowned James Woodhouse. Seybert was absolutely convinced that the metal of the zinc ore could be readily isolated and applied in a thousand different ways in the arts. His opponent argued that the metal had little practical value; that its isolation would be unsatisfactory and expensive. Seybert was in the right.

But while Woodhouse erred in this case, his intense

enthusiasm and interest in the question of baking was productive of good. Household economics was a term not then spoken but what constituted household economics was, in part, in the minds of these pioneers, and the study of baking to which Woodhouse had recourse was beneficent in its results. This study included the flour, the yeast, temperature, etc. It was unique but very modern in its conclusions, and was another example of where *utility* might be written across the face of our science.

The modernist will ask impatiently—was there no research? That talismanic word had touched chemists, in the close of the 18th and the beginning of the 19th Centuries, lightly. Joseph Priestley was with us, indifferent to utility, self preservation, protection or any of the dominant ideas which had prevailed before, and he now threw into the ring a new apple of discord—the constitution of water, the existence of an enigmatical, evanescent phlogiston. The sensation created by him was laid low, and in doing this there came for a moment, an insight into a new field of chemical activity. The curtain had been raised a bit and those, fortunate enough to get a view of the new possibilities, were eager to penetrate further, but stern necessity held them in leash a little while longer.

The finding of the oxyhydrogen flame in 1800 by Robert Hare—was it the result of a desire to investigate and further learn the properties of the constituent gases? I fancy not. Hare, aware of what occurred on blowing air through a blowpipe, into a flame, naturally asked whether the intensity of the same flame could not be increased if oxygen were substituted for air, and then it was but a step to the introduction of oxygen into a burning hydrogen flame, when a degree

of heat was obtained far beyond that which chemists had at any previous time possessed. And what were the results? The beginning of industries which had platinum for a basis; the beginning of efforts which had illumination as an important feature. And—it was still *utility*, written in red letters across the scientific investigator in chemistry.

Today, chemistry in the arts has brought to pass a condition astonishing and marvellous. Men stand in awe of the products of applied chemistry, in awe of the wonderful conquests following the introduction of the principles of chemistry into the utilization of raw materials.

Turning again to the fathers, we find that as our country rapidly progressed along many lines, as it expanded, as new centers appeared on the map of the United States, there were those who, fascinated by the conquests of chemistry, turned their thoughts to the elucidation of the constitution of matter, to a solution of the constitution of many of the products which have been synthesized and a solution of the constitution of natural bodies. There was then a little more time—a little more leisure in which such questions could receive consideration. Industries were springing up on all sides, but the search into the constitution of matter had not yet extended very far.

It is true that in 1808, potassium had been isolated by an original method, but no one was greatly exercised over the discovery. It caused so little excitement that it failed to find its way into the literature, but the masses were being entertained by delightful and interesting experiments, exhibiting the wonders of the science. Books were being published, some of them reprints, many of them original productions of native

chemists; but the spirit of investigation or research was not yet the dominating, driving force. It was only toward the close of the first quarter of 1800 that we were beginning to hear of an electric furnace, of the use of mercury as a cathode, and then in the little laboratory of that giant in chemical thought and investigation, Robert Hare, down in Philadelphia, there was undertaken a piece of research work which had not for its purpose and end—*utility*, but the desire to know whether a positive group, such as the ethyl group, could take the place of hydrogen in inorganic acids. Berzelius said compound ethers were composed of an acid radical joined through oxygen to an alcohol radical, and two young men in Hare's laboratory, cognizant of the views of the great Nestor of the North, questioned whether in an acid, like perchloric acid, hydrogen could be replaced by the ethyl group, and speculated as to the nature of the product. They had success. They obtained ethyl perchlorate, a liquid boiling at 74° C., unstable, having an explosive force exceeding that of gunpowder, exceeding that of nitrogen trichloride. They strove to apply it but it was so unmanageable that their attempts were discontinued. It was a noble piece of work. It passed unnoticed. Twenty-four years later Sir Henry E. Roscoe, coming upon a description of this unique body—ethyl perchlorate—restudied the efforts of Clark Hare and Martin Boyé, confirming the same in every particular. It is a joy today to some of us to reflect that this early problem in pure research in organic chemistry proved so invulnerable.

And in the same group of students gathered about Robert Hare were Channing and Wolcott Gibbs, who, inspired and incited by the efforts of their associates,

prepared methyl perchlorate, not mentioned anywhere in our literature, not even in Beilstein, where ethyl perchlorate is incorrectly credited to Sir Henry E. Roscoe.

These examples show that the spirit of research was with the early American chemist, that he, too, when the great problems of utility, self preservation, protection and independence were attended to, was quite ready to study the science for itself.

And don't forget that it was in 1830 that Samuel Guthrie, by an unusually brilliant idea, gave us chloroform. The classic method of its production from alcohol and bleaching lime was his contribution to pure science, little dreaming that the resulting product, prepared by him in large quantities, was to become a benign influence in surgery.

In this period, too, came the first venture in the re-determination of the atomic weight of a metal; namely that of aluminium, by Mather of West Point.

The name Booth, Garrett and Blair has a familiar sound to every ear in this audience. Booth, the founder or originator in our country of chemistry as a factor in commerce and the recognition of the chemist in the economy of the world's work, while absorbed by ventures into the field of scientific literature, was in 1849 called to be Melter and Refiner in the Mint. This was coincident with the discovery of gold in California. The gold from this field required intricate and at the same time accurate and prompt treatment to fit it for coinage. Under Booth's supervision, a process, until then little more than one of the laboratory, was expanded into that of a factory. To this problem he brought all his experience in the science. This gold pressure continued on him for five years. He succeeded.

His country enjoyed the benefits. His whole conduct was that of his great predecessors and like them he rejoiced that his science could thus serve country and fellowmen. Now, he was free to turn thought to the more enchanting field of research—study for its own sake! but he wrote

> I went home quite sick from the Mint early in April and I lay on my back for three months . . . . It was that constant and constantly augmenting ounce for ounce responsibility that finally . . . . broke me down.

A martyr in the application of his science to the needs of his country.

Colleges and universities sprang up, at first indifferent to our science, but gradually its home, and in them the spirit of research—of the study of the science for itself without any consideration as to the utility of its product—was fostered. In the great world of manufacture, chemical research should accompany the practical. In the centers of learning research should be emphasized. It should be the purpose of the teachers of our science to point the neophyte to the opportunities for thought and effort in the many ramifications of our science.

Analysis in chemistry is by many looked upon with contempt and yet there are untold possibilities there deserving the closest attention and the best thought of all who give themselves to this particular branch. Research in organic chemistry, in physical chemistry dominate the investigators of the day; yet research in applied chemistry is worthy of just as much consideration under the protective influence of the university professor as the favorites to which reference has just been made. No, chemistry is chemistry. And while we congratulate the physicist on his wonder-

ful study of the atom, while we follow him in his explanation of electrons, the function of the negative and positive electrons, the constitution of the nucleus, etc., ours is the study of the behavior of matter, its constitution, and our science can never be other than an independent science, ready, of course, to use all the aid that can be brought to it in the solution of its stupendous problems.

And as we permit this panorama of the development of chemistry to pass along it impresses one as being an epitome of like occurrences in other lands. Recourse to the pages of that voluminous and exhaustive treatise "History of Chemistry", 1797, by Ferdinand Gmelin amply confirms this declaration. In lands, where now theories and devotion to the science for itself flourish most exuberantly, was once heard nothing but comments on crude material, its value and its conversion into *useful* products. The French revolutionary wars frustrated the importation of the sadly needed sodium carbonate, so that LeBlanc's synthetic process assumed great importance and enjoyed a long, and in many respects, a prosperous life.

Later, was it for gain or humanity's sake that the indigo synthesis engaged men's profoundest attention? Whichever it may have been, industrial chemistry won a powerful, all convincing argument in its favor, and incidently the Far East ceased to be the land of devastating famine. This example has in it *utility—preservation*—and *study of science for itself.* It splendidly illustrates chemistry's many-sidedness, and its nearness to man.

When Winthrop, in the sixteen hundreds, sent to England from Connecticut a shining, heavy mineral which lay for years on the shelves of the Royal

Society, he dreamed not that in due course Charles Hatchett, *bon vivant*, man of the world, and chemist, would in 1701 announce that it contained a new metal, which he called Columbium, from Columbia, the new home of Winthrop. And this same Hatchett must have even then revelled in the wealth accumulated from the application of chemical principles, for Thomas Thomson, in his fascinating history, despairingly laments Hatchett's loss to science as the outcome of the baneful effects of wealth acquired in scientific pursuits, which story I am disposed to believe, because in my collection of autograph letters from early and modern chemists there is one from Hatchett ordering from a dealer "a dozen bottles of Lafitte Claret, and one bottle of Ratifia de Grenoble" the same to be sent to his dear friend Professor W. T. Brande, head chemist of the Royal Institution and delightful author of valuable chemical texts; and for himself friend Hatchett ordered "Six Bottles of the same Champagne as the last, Six Bottles of the same Port as the last, and Six Bottles of the La Rose Claret as before."

Chemistry is the noblest of sciences. That will not be disputed after a little reflection. It is true because it is so human. Some one has characterized Botany as the "amiable science" and I presume qualifying adjectives might be assigned every one of the various sciences, but to chemistry alone belongs the designation *human*. Note how medicine leans upon it. There are those, medical men indeed, who frankly concede chemistry's all importance. It has brought to recognition preventative medicine and is daily adding to its dominant place in medicine by fresh and wholesome discoveries. Physics, a sister science, has greatly aided chemistry, but physics is not chemistry, which, as

already declared, is concerned with material change, and is fully able to suggest to the physicists new fields for cultivation, and provide a fresh stimulus to his research. Let him, for example, in some simple way solve the phenomena of valency. The "modern physiologist revels in colloids, osmotic pressure, hydrogen-ion concentration, etc. and thus sets us new problems for solution." So again, we observe the fundamental importance of this human science. The pursuit of its history is most fascinating. It runs from the deepest utilitarian to the loftiest and most transcendental ratiocinations, suddenly dropping us on the plane of the human. On one occasion the celebrated Wöhler, to whom it was my privilege by means of pencil drawings of hexagons, etc. to explain the course of an investigation, said

> These are air-castles. I do not understand them.

What would he say to the map-drawings resorted to by physical chemists of the present?

But all these vagaries have a value. However, judgment must be exercised lest the genuine products of research are buried under the rubbish of hastily and ill-conceived theoretical notions. It is authoritatively known that the ideas of Wenzel, relative to definiteness of combination, were suppressed because a coterie of mutual self admirers testily pronounced the work worthless. Inability on their part to understand and interpret the experimental data of Wenzel, as well as an unjustifiable jealousy of their author, not of their "set", postponed the recognition of his pioneer efforts. Like circumstances contributed largely also to the sequestration of the even more brilliant observations of J. B. Richter, which long lay undisturbed and, indeed,

forgotten until a later generation, indifferent to his social status and unencumbered with likes or dislikes, brought his remarkably illuminating experimental work to the day.

Where there is imagination able to carry beyond the present and to suggest new ideas and new trains of thought, whether it be in the factory or in the university laboratory, there research will prevail and produce worthwhile things, if that imagination be accompanied with reason and judgment. The eager, insistent advocate that *he* alone is capable of research, that the humdrum of daily ordinary chemistry is not for such as he, should ponder well the fact that it is only now and then that an all-wise Providence places an approving hand upon the head of some earnest, devoted, thoughtful student and ordains him for the higher philosophy. But let me cease this dreamy rambling which readily leads one far afield, and be content to advise and follow patiently the noble admonition—prove all things and hold fast to the good.

But as one reviews the history of chemistry in America or in other lands, is it not evident that its philosophy is read in man's own aspirations? The science is so much of himself, a being whose earthly existence is shot through and through with those changes in matter with which the science busies itself, that his history and its history are interdependent and mutually inseparable.

Contributions of Science to Industry and Engineering—A Symposium

CHEMISTRY

by

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Read at the Meeting of the American Association for the Advancement of Science, Section M (Engineering), at Philadelphia, December 29, 1926.

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Mrs. Francis P. Garvan, and conducted annually by the American Chemical Society in the secondary schools, public and private, throughout the nation.

Why, then, should I endeavor to augment what already has been so well done? One reason only—the full realization of how unevenly the processes of dissemination proceed and how necessary it is to repeat over and over again if we hope eventually to reach all.

Chemistry and Industry

But with the necessarily limited time at my disposal to-day, certain pertinent chapters must be chosen as illustrative of the prolific contributions of the science of chemistry to industry.

Much of our chemical industry was originally developed through pure empiricism, but the applications of new principles derived from pure science have revolutionized these industries and carried them forward with infinitely greater strides. Meanwhile, these same concepts have brought into being new industries which have enriched the world.

What branch of chemical industry is not indebted to John Dalton for his atomic hypothesis and to Avogadro for his supplementary conception of the molecule? What peace of mind could any manufacturer have if Lavoisier had not heralded the quantitative period in chemistry? Visit Niagara Falls and see the great electrochemical industries—then think of Michael Faraday and his fundamental concept. Watch the car loads of corn going into the great fermentation plants in the middle west or the tank steamers at Baltimore arriving with molasses, the waste product of Cuba's great sugar crop, then read the "Life of Pasteur."

First Aniline Dye

In 1856 Perkin, seeking to prepare quinine from aniline, accidentally brought into existence mauve, the first aniline dye. It is not difficult to believe that had we been dependent on such casual methods alone progress in the field of coal-tar compounds would have been halting and uncertain. Kekulé in 1865, with his vision of the structure of the molecule of benzene, C_6H_6, changed the situation completely. The evidence marshalled to support his belief that in this molecule the six carbon atoms are linked to each other to form a closed chain made clear many facts which could not theretofore be explained. Of far greater importance, this concept of pure science presaged the discovery of many new compounds. Order was brought into the whole system of coal-tar compounds, and research on the production of thousands of these derivatives was feverishly stimulated. Upon the basis of this

fundamental theory have grown our great coal-tar industries—synthetic dyes, medicinals, aromatics, flavors, photographic chemicals, high explosives and many war gases.

Ammonia Synthesized

At the eighth international congress of applied chemistry, held in New York City in 1912, Professor Bernsthen, of the Badische Anilin und Soda Fabrik, gave a lecture, with demonstrations, on the synthesis of ammonia from hydrogen and atmospheric nitrogen by passing the mixed gases over a catalyzer at increased temperature and pressure. He announced the laying of the foundations of the first plant for the manufacture of synthetic ammonia. This was the industrial application of the brilliant research in pure science by Professor Haber. As a climax to his demonstration, Professor Bernsthen held a piece of white cloth before the exit tube of the apparatus, and as the ammonia fumes touched the fabric it was rapidly transformed into an American flag which the professor enthusiastically waved before the audience. Little was it realized, as we applauded the striking phenomenon, that within a few years, as a result of this successful utilization of pure and applied science in Germany, thousands of American lives would be sacrificed as they followed that flag on the battlefields in France.

Not many years ago the producers of cottonseed oil in our southern states spent much time and money on fruitless efforts to persuade the housewives to substitute this liquid fat for lard, the semi-solid fat of the hog. Meanwhile, in the quiet laboratories of a French university, Sabatier and his co-workers were deeply engrossed in a pure science study of the transformation of unsaturated to saturated organic compounds. Sabatier showed that the addition of the necessary hydrogen atoms could be readily effected by the use of finely divided nickel as a catalyst. Cottonseed oil is a mixture of glycerides of unsaturated fatty acids. On hydrogenation by Sabatier's method there resulted saturated compounds which were solid. Then by careful regulation of the hydrogenation process of semi-solid fat, a true synthetic lard, was produced. The prejudices of the cook thus overcome, a great new industry was created, and again pure science had made industry its debtor.

An Epochal Advance

While organic chemists were absorbed in developing the many new lines of work suggested by Kekulé's views, there appeared in the Transactions of the Connecticut Academy of Sciences, in 1876, a contribution so cloaked in mathematics that chemists did not realize that Willard

Gibbs' phase rule was an epochal addition to chemistry. When years later it became understood, its application brough clarity and scientific basis to many processes which previously had been purely empirical. Industrial applications were rapidly made. The whole field of alloys, particularly that great tonnage alloy, iron and carbon, took on a new light; the problems of Portland cement became clarified; and in a multitude of other lines this fundamental research proved of inestimable value.

Sometimes, however, the worker in pure science is discouraged by seemingly unfortunate properties of the material with which he works. So in 1872 Baeyer found that phenol and formaldehyde formed a condensation product, but it was not crystalline. He saw no attraction in study of the gummy, resinous mass. Baekeland, however, boldly attacked this problem, and created the new synthetic resins, the uses of which seem to be unlimited.

The beautiful finish on our automobile bodies to-day is an illustration of the complete revolutionizing within the last few years of an old, established industry, that of lacquers, made possible by the work of Whitaker and his research staff in the U. S. Industrial Chemical Company. All accepted methods for making ethereal salts, such as ethyl acetate, involved high concentration and a dehydrating agent. This meant high cost, for the available acetic acid varied below 15 per cent. concentration. Whitaker resolved to put his whole staff on a pure science study of the question of esterification. Rates of reaction between alcohol and acid, equilibrium conditions, concentration of catalyzers, and similar problems, were thoroughly studied. To quote his own words: "Months were required to complete these investigations, but the facts once established presented an entirely new view of the problem, saved months of time spent on mistakes, or perhaps avoided final failure." The net result of the work was the installation of a continuous process for esterification of dilute acetic acid, from which there is produced a monthly output of 150,000 gallons of chemically pure anhydrous ethyl acetate.

In the preceding illustrations, mention has repeatedly been made of the use of a catalyst, a substance which affects markedly the rate at which chemical reactions proceed, without itself being affected by the reaction. Here the purest of pure scientists have been gross empiricists. Catalysts have been used for many years, but the selection of the proper catalyst has been the result of haphazard discovery or the application of the "cut and try" method. Yet we are dealing with one of the fundamental principles of chemical reactions, and, from the standpoint of industry,

with one of the greatest dividend-paying agencies. Shall we rest content with empiricism? Do we not know, from all other experience in matters chemical, that when once we understand the scientific explanation of catalysis we may look forward with confidence to the opening of entirely new chapters in chemistry and its application?

Princeton University Leads

Fortunately, Langmuir has brought some light into this all too clouded field. To-day Princeton University, through the work of Hugh Stott Taylor, has become the center for the scientific attack on this problem. It is a sad commentary that, in this period of construction of magnificent chemical laboratories in our universities throughout the country, Taylor's work must be carried out in the old and dingy basement of a laboratory utterly inadequate and ill-suited to the needs of a great university.

This thought brings me to a fundamental question: "How should research in pure science be supported?" Are most favorable conditions for its successful prosecution to be found in our universities, in the research laboratories of our more progressive corporations, or in endowed institutions?

The resources of the universities, whether derived from taxation or endowment, are frequently too limited to provide adequate equipment and sufficient associates to ensure the maximum output of men of fine talent, and too often their research is spasmodic, interrupted by teaching duties and administrative responsibilities. Yet research work under the influence of a noble teacher, and within the walls of a great university, is inspiring. From this source, too, must come the supply of well-trained research workers.

The seductive allurements of the larger salaries offered in industrial work have so depleted our university staffs that industry is at last awakening to the short-sightedness of this policy. That is the solid foundation on which rests the appeal of Mr. Hoover's committee. The successful culmination of their plan for support by the industries of university research is pure science, to the extent of $2,000,000 annually for ten years, would restore the equilibrium.

Petroleum Problems

One can not but rejoice in the awakening of the petroleum industry, as evidenced by recent contributions to aid fundamental research in the pure science hinterland of that industry. Under the direction of the American Petroleum Institute, problems suggested by a group of scientists are being assigned to those workers in university laboratories whose experience and equipment

seem best to meet the needs of a particular study.

From the research staffs of industrial laboratories contributions to pure science will continue to be received. It is a wise investment for a corporation thus to make sure that it will be the first to realize upon the practical application of a new development in pure science. Yet research in pure science will always necessarily be of secondary importance in an industrial organization.

From privately endowed research institutions we have a right to expect real contributions to pure science. Their staffs are not under the seeming necessity of frequent, and therefore often premature, publication as offering the best means for preferment; nor are they under the pressure of making an immediate showing to directors more interested in the treasurer's balance sheet than in the report of the director of the research laboratory.

Excellent as have been the results from all these existing agencies, the fact must be faced that in none of them is the matter of research in the pure sciences the primary purpose and goal of the organization.

Co-operative Research

I remember well my last talk with the late beloved Dr. Wallace Buttrick, of the General Education Board. He had been besought to recommend financial aid to an undertaking in a rather restricted field of scientific research. He told me that he couldn't get up any enthusiasm for the proposal, that more and more he was coming to the conviction that funds should be found for creating a great institution where our ablest scientists could carry on fundamental research in all branches of science under conditions as nearly ideal as could be furnished. That was the ripened judgment of a man who had given the many busy days of long life to aiding every form of education and research. His thoughts were always progressive; his feet always upon the ground.

If Dr. Buttrick was right, and I hold that he was, where should support for such an undertaking be sought? Granting as axiomatic that progress in applied science is strictly delimited by the advances in pure science, who would profit most? The answer is—each and every one of us. Not the manufacturer, except incidentally. Witness the constantly lowered cost to the consumer of electric lighting, of automobiles, telephones, aluminum, and a host of other commodities.

If, then, we the public are the chief beneficiaries of the advances in pure science, it behooves us as thrifty citizens to busy ourselves with the problem of providing those ideal conditions

which will ensure the maximum output which the human brain is capable of producing.

Federal Support Necessary

How can such collective action be taken? By federal taxation and Congressional appropriation of funds adequate for the creation and maintenance of a national undertaking where ideal conditions for research in pure science both as to personnel and equipment, will be afforded.

I know full well the many objections to such a proposal which arise at once in your minds. Of course the next Congress would not appropriate funds for this purpose. Naturally politics would make itself felt in such an institution. Governmental red tape would certainly be restrictive on originality. These, however, are conditions of to-day. I am not of those who scoff at Congress. Our representatives in Washington, I believe, endeavor to carry out faithfully that which they are confident is for the best interest of the whole nation. They fairly represent the average thought of our people.

My proposal is based upon the assumption that the men of science will during the next few years carry on an even more intensive campaign in popular education which will result in each citizen seeking clearly how much he has at stake in this matter. Confidence in the reasonably early success of such an educational undertaking is begotten of an intimate knowledge of the ways by which our people have so quickly grasped the facts of the close relation chemistry bears to their everyday lives. That was no miraculous revelation, but the result of the thoughtful, earnest, self-sacrificing work of many men who deemed it primarily a duty to their country—and they have gotten a lot of fun and happiness out of doing it.

With a nation thus aroused as to the determinative influence pure science has on human advance, Congress could not fail to heed the popular demand that an adequate part of the country's taxes be appropriated for this worthy purpose.

Reprint from the ASSOCIATION OF AMERICAN COLLEGES *Bulletin*
March, 1928

RESEARCH IN COLLEGES

PROFESSOR MAYNARD M. METCALF,
Johns Hopkins University

During twenty years of teaching I have been accustomed to talk to my pupils, especially to those who were nearing the end of their college course, upon the educational value of intensive study of some subject, however small, to the point of mastery and of confidence in mastery of that subject, urging them, if they could not go on to regular graduate study, at least to take up something, even if nothing more than the habits of some insect in their back yard, or some feature of the history of the town in which they live, or anything else that appeals to them, and follow it until they know a lot about it and until they know they know a lot about it. If by good fortune they could find some man of established reputation making some reference to this subject, and being mistaken, so that they could correct him, however much of an authority he might be, then their feeling of confidence in their own mastery would be strengthened. They would then realize that they were themselves authorities in their little field, and having once become an authority each would forever after despise authority. Emancipation from subservience to authority, from the fear of the printed word, is an essential step in the acquirement of a real education, and any education that stops short of this point is essentially defective. An educated man should think, not under the dominance of men of scholarly attainment but independently, judging others' work as he would judge his own, realizing the fallibility of the scholar. He should think *with* them as a fellow student, and not overawed by their reputation.

I believe that no man should be teaching in college until he has reached this point of justified respect for his own judgment. This argues of course that no one who has not engaged in scholarly work of a productive sort, whether or no he has published, should be admitted to teaching in college. In common parlance, the Ph.D. degree, or its equivalent in training, should be demanded of all teachers in college.

But this is not enough. Productive, independent scholarship should continue. The graduate student gets only a start in the university. When he becomes a teacher the spirit of independent scholarship, of productive scholarship, needs to grow and strengthen if he is to teach masterfully rather than subserviently, if he is to have in his teaching that quality of inspiration which is the crowning glory in a teacher. Knowing his subject is the first thing. He also must continuingly study teaching method, finding and improving his own method. And *his* method will not be exactly the same as any other man's. Independent observation and independent judgment of his job and of himself in his job is essential. But of at least equal importance with expertness and faithfulness in teaching method is the quality of inspiration, for which, at its best, there is necessary a genuine devotion to one's special subject, devotion to the point of sustained service, in order that knowledge of his subject may increase through his labor as its devotee. The most inspiring teaching calls for an enthusiasm for the subject that finds outlet in productive study, vital interest so keen that it sustains the teacher in the drudgery which is a large element in productive scholarship. Essential to the most worthy teaching are knowledge, method and inspiration, these three, and the greatest of these is inspiration.

In a teacher the spirit of productive devotion to his subject and of keen enjoyment in it, in spite of the drudgery of true scholarship, is highly contagious. We should expose our college students to this contagion. How can they

realize the satisfactions in the intellectual life, in the search for truth, how can they acquire the productive spirit and feel the urge to intellectual adventure, in any other way so effectively as by close contact with mature minds quickened by this spirit. We owe it to these students to bring them into such contact.

College students in general choose their life work during their junior or senior year. If they are to choose the life of productive scholarship, this life must be vivid to their imaginations—and how can this be unless they have had vital contact with men full of the research spirit, devoting their lives to the search for truth and to helping others get in on the fun of this great game. We need college teaching, instinct with the idea of Growth, *growth* of knowledge in the past, present *growth* tendencies, needs for future *growth* in specific directions, avenues of approach to solution of imminent problems—such teaching as will stir the spirit of intellectual adventure in the students and will make vivid to them the fun of the game; and all, of course, with the background of service to society, a religious devotion to truth, its discovery and its loyal application, its loyal living.

It isn't only in the library and in the laboratory that this devotion may be shown. Every man in his job, whatever it may be, if he has caught the spirit of discovering the new and applying it, can exercise this spirit of production. It is not only the ablest college students who should feel it. It's a sad thing for any college man to fail to get at least some of it. It was with the hope of stimulating the intellectual life of the college, of infusing it to a higher degree with the contagious spirt of intellectual production, as well as of intellectual appreciation, that some of us have stirred up discussion of research in colleges.

Certain things are especially needed and certain others are very helpful in the encouragement of college teachers in research.

(1) Let it be expected of them, and let them receive consideration for its successful accomplishment.

(2) The demands of teaching and of committee work should be so planned as to leave a reserve of energy and of time for productive scholarship. This, when thought through, involves a small student body and a large faculty.

(3) Salary should be sufficient to free the teacher from the necessity for gainful occupation outside of his regular teaching.

The relations of the college administration to the teacher and his research deserve careful thought in each institution. First, in all our conferences and discussions major emphasis has been placed upon having a *research committee* in the college. Second, a *research fund,* preferably at the disposal of this committee, from which grants may be made from time to time, has been found of the greatest value, Third, in each departmental *budget,* appropriation should be made for the reasearch of each teacher in that department if he needs such appropriation. Fourth, *clerical work* should be done by clerks and not by teachers. Fifth, research assistants are just as useful and as natural as are assistants in laboratories or in other phases of teaching.

Quality of product, that is, of graduates, not quantity, is the worthy ideal. Limit numbers to the point where good teaching can be done. Get rid of the less worthy students. If such high-grade college work cannot be given with present facilities to worthy students seeking it, let more funds be provided. It is up to the community. But do not consent to let pressure of numbers cause acceptance of low-grade college teaching. Seek quality, not quantity.

All this is expensive. *Good* teaching is very expensive but only *good* teaching is thoroughly worth while. There should, therefore, be given to the colleges financial assistance for the support of the research of their teachers and for the reduction in the hours of teaching to the point where worthy research becomes possible and attractive to them. An attempt is now being made to present this need to some

of the foundations interested in education, the point of view being better teaching, teaching with contagious inspiration to the search for truth, the contagious spirit of production. But there is a second end in view, namely, the securing of a larger percentage of the ablest college graduates for the life of research. The same means which quicken the intellectual life of the college will stir the intellectual ambitions of the students and direct more of the ablest of them into productive scholarship, and into the best type of college teaching.

As a matter of sad observation, it is true that there is a most unfortunate slump in the research of young doctors of philosophy when they begin teaching. This is not altogether unnatural. When the young man begins his teaching he is faced with a somewhat new set of problems which gather around his need for working out his best teaching method. It is especially important just at this time that he be helped to keep the proper balance between his own scholarship and his attention to teaching method. It is disastrous if he fails in either direction. The colleges have as a matter of fact been remiss in failing to stimulate adequately the young teacher either in finding himself as a teacher or in continuing his productive scholarship. But they have been more remiss in the latter regard. Inspiration is even more important than method and productive scholarship is the best stimulus to teaching which shall be full of inspiration.

During the last thirty years or so much has been done to increase American emphasis upon research. True research universities have been developed. There are some very effective institutions for research alone, unassociated with teaching. In the universities are many scholarships and fellowships for the aid of graduate students. In a number of important subjects there are research fellowships available for young doctors of philosophy, but the policy of administration of these fellowships has barred teachers on a year's leave of absence from receiving them. The Guggen-

heim Foundation gives research fellowships to a few somewhat more mature scholars, but in general there is very little financial encouragement and aid available for established college teachers in the prosecution of their researches.

The existing aids for research hardly register as stimuli to college students to enter upon the life of research. They do not aid college teachers and quicken their spirit of productive scholarship. The appeal to the intellectual life and to productive scholarship needs to be strong in the college as well as in the graduate school. Great things have been done for American scholarship, but the effort and money so expended have not had their proper full effect. A comparatively very small further expenditure, carrying the stimulus down into the college will have a disproportionately great effect by completing the circuit between the growing American spirit of productive scholarship and the college students, from whom research recruits must be drawn.

You are familiar with the attempts which our group has made to stir up discussion of this subject among the colleges. The Joint Committee upon Encouragement of Research in Colleges,* to which your Association furnished one of the seven members, is now seeking financial cooperation between foundations outside the colleges and such colleges as are willing to undertake specific aid to the research of their teachers. We are seeking a fund from which grants can be made to certain institutions in which there is an atmosphere of encouragement to research and which are willing to cooperate somewhat extensively financially with those who are in charge of the funds.

We are recommending several types of assistance for the research of college teachers and we urge that in every case the college shall furnish part of the funds.

We recommend that the assistance given reach all grades of teachers from instructors to full professors, and that,

* Dr. Metcalf is Secretary of the Committee. The Association of American Colleges is represented by its Executive Secretary.

among other things, time shall be secured for them for uninterrupted research. We are recommending also that research funds set aside by the college to be used in grants by its research committee shall be increased from the fund which we are seeking to establish.

These are but a few of the many things that may be done, and we believe done effectively, in promoting research by college teachers. With financial conditions as they are and even with the conditions of overcrowding that obtain in so many of our colleges, we believe that much can be done by each college to improve conditions for research by teachers and to stimulate such research. Suggestions toward accomplishment of this, which have been elicited in four conferences and many discussions and by much correspondence, have been arranged, printed and distributed to all of the colleges in America which have as much as one million dollars of endowment and to a good many which are not so listed. Our committee believes that there is much value to be had from such financial assistance for the colleges as we are now seeking, but even more important than this is thorough consideration of the problem in each college, the recognition of the fact that research deserves a place in the college and should be as carefully planned and as truly suported as the teaching itself. Thoroughly planned interchange of ideas between colleges as to research support should be had.

Indeed, regular cooperation between colleges in very many features besides that of planning research should be a great element in the plans of all colleges, bringing about great saving of human energy, and of millions of dollars by avoidance of waste from only partial use. But this is another story not to be entered upon at the end of a paper restricted to twenty minutes. The final thing to be emphasized is the need for thoroughgoing, painstaking, individual and cooperative study and effort by the colleges themselves with a view to quickening their productive intellectual spirit.

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THE BERTHELOT CENTENARY AND THE RESULTING INTERNATIONAL EFFORTS TO ADVANCE CHEMISTRY[1]

IN January last I had the pleasure of describing before the Chemical Society of Washington the celebration of the centenary of Marcelin Berthelot held in Paris from October 24 to 26 of last year. These remarks have been published in SCIENCE (Feb. 17, 1928) and possibly have been read by some of you.

Through the kindness of the French ambassador and M. Maurice Léon I am able to show you to-night a photographic record of the event, which will certainly give you a more vivid impression of it than I was able to convey by words alone to the chemists of Washington. Thanks to this pictorial presentation it will not be necessary for me to review again the details of the various ceremonies and more attention can be given to other aspects of the event.

Considering the celebration in its entirety there is no question but that it was the most magnificent tribute to chemistry but has ever been organized. More than fifty nations of the world sent distinguished chemists or governmental representatives. The president and entire government of France as well as the ministers and ambassadors of many other nations participated. Chemistry was extolled more highly than ever before. Judging by the space devoted to it by the newspapers the celebration attracted the at-

[1] Address delivered before the joint meeting of chemical societies at the Chemists' Club, New York, April 6, 1928.

tention of the general public to an extraordinary degree.

The gathering was noteworthy in being the first since the great war at which the chemists of the enemy nations have met together under such amicable circumstances. An especial effort was made to reestablish cordial relations between all, and the evidence of success in this direction was unmistakable.

The assemblage was unusual in that no other attraction than friendly regard drew the participants together. It is true that in the preceding week a program of chemical interest was provided by the Société de Chimie Industrielle, but at the Berthelot celebration nothing was presented other than discourses on Berthelot and the plan to perpetuate his ideals in regard to cooperation among scientists.

As expressed by Berthelot science is a collective endeavor and owes its progress to the efforts of workers in all countries. It is truly international, and of all men scientists should be most interested in promoting friendly international relations. This was undoubtedly the keynote of the celebration and in emphasizing it French chemists demonstrated their outstanding interest in cooperative efforts to advance chemistry.

The desirability of intimate contact between those engaged in chemistry does not need to be emphasized. It is true that we may become acquainted with other chemists through their publications, and to many this is sufficient, but to others there is nothing so stimulating as personal intercourse with those interested in like problems. Any means which facilitates this contact may be expected to advance chemistry. This is believed by its sponsors to be one of the missions of La Maison de la Chimie.

The Chemists' Club of New York, although a local undertaking, has become a most powerful agency for the advancement of chemistry. It offers membership

to chemists outside of New York and thus extends its field of usefulness. The Maison de la Chimie which will be erected in Paris will serve primarily those in its immediate vicinity, but it will also do for the chemists of the adjoining and other countries what the Chemists' Club of New York does for those of us who reside in other parts of the United States.

There is this difference between the two undertakings—whereas those who founded the Chemists' Club probably did not realize what an important factor for the advancement of chemistry they were inaugurating, the sponsors of La Maison de la Chimie are knowingly setting out to establish an international center for this purpose. Thus they have the advantage of a predetermined plan and a definite goal.

It can not be denied that such a center located in Paris will be of great service to the chemists of a large group of European countries. It is of course not so certain that many American chemists will be directly benefited by it. This, however, should not be a reason for the indifference with which the project has been received in our country. A more correct explanation of the attitude of American chemists is undoubtedly the great distance which separates us from Europe and the huge task in hand of developing chemistry in this country. We are captivated by our own affairs and will not allow our attention to be distracted by circumstances which we believe do not directly concern us.

There is, however, another reason which accounts for some of the criticism expressed by our society at Detroit. It was the solicitation by the French government of collaboration in the undertaking. We naturally question any governmental participation in scientific matters because we feel that anything having a political flavor can not be above suspicion. This, however, is an attitude which is peculiar to our coun-

try. In practically all others, it is the government which directly supports science. In France, for example, all the leading men of science in their capacity as professors in the universities or directors of institutions are government employees and every action they take in international affairs is with the financial and moral support of their government.

The movement for an international Maison de la Chimie was initiated by the chemists of France, but its realization would have been impossible without governmental aid. The reason it obtained such full support from the French government was that the prime minister and many of his associates are themselves scientists of the highest standing and have the very fullest appreciation of the benefits resulting from the progress of science. Berthelot was in his time minister of public instruction and Herriot, the present minister, occupied a prominent place in the ceremonies planned in honor of his predecessor in office. The close relation which exists between the governments and science in other countries was also shown by the number of ministers from other nations who participated in the Berthelot celebration. Finally, the small countries and colonies which contributed to the movement could have done so only through their governments. As with all other countries, the appeal to the United States to join in this movement was addressed to our government. It was the natural method, and if an exception had been made in our case and the request addressed directly to our society the action would have been considered, from their point of view, as one of disrespect to the United States government.

The fact that the leaders of our government are not men of science and that there is not a closer relation between science and government in the United States is regrettable. It is to be hoped that the organized

effort to popularize science, being made by Science Service and the American Chemical Society (A. C. S.) News Service, may eventually arouse our government to greater interest in its benefits.

In another respect, however, we are particularly fortunate. It is that in the United States we have a single language and no political barriers between different sections of our great country. These handicaps exist in Europe, and the cooperation of the smaller groups of chemists in the various countries can be effected only by overcoming much greater resistance than oppose our efforts in America. It is this situation which makes desirable the concerted effort represented by La Maison de la Chimie. Aside from the countries in which the English and German languages are used there are many in which French is either the native or preferred language. These Latin countries are sorely in need of coordination of their efforts in respect to the dissemination of chemical literature. A central clearing house which can serve them in the way chemists are served by the organizations in Germany, England and America may be expected to facilitate greatly their contribution to the advancement of science. The International Office of Chemistry which will be given shelter in La Maison de la Chimie will undoubtedly perform an incalculable service to a large number of chemists in many different countries.

There is, however, a very difficult problem which confronts those interested in the establishment of this new project. Beginning now after such an extensive literature of chemistry has accumulated, the collection of a considerable part of it is a costly and laborious task. Even to establish a comprehensive French abstract journal for current contributions is a great undertaking, and with the present acceleration in the

output of chemical publications necessarily becomes more and more difficult.

While talking to M. Gerard some months ago he told me of these problems and gave me a hint of a possible means to solve them. Although the solution he contemplated would necessarily be an experiment it would be one which the rapid increase in scientific literature is certain to make necessary sooner or later. Any improvement in the distribution of scientific literature is certainly desirable and the results of the experiment to be made by the International Office of Chemistry will be awaited with the greatest interest.

The plan contemplates the reproduction of printed chemical articles by a cinematographic process. The pages will be photographed upon a film and this sent to the user who will project it page by page before him on his desk and to such an enlargement as best suits his vision. The disadvantages to some resulting from the use of small type by certain journals will thus be avoided. Abstracts which attempt to give the substance of a paper will not be necessary, since the entire article may be sent out for a cost which it is expected will be no greater than that now required for preparing, editing, printing and distributing an abstract journal.

In order to acquaint chemists with the current articles as they appear a card catalogue system will be employed. The cards will be efficiently classified and describe only the scope of the paper. Each member will receive cards for the particular branches of chemistry in which he is interested and will select from these the papers of which he desires photographic copies.

This will be in effect a new kind of bibliographic service, and its success will of course depend upon the ingenuity displayed in perfecting the photographic apparatus required and the efficiency attained in the

preparation and classification of the cards covering the current chemical literature.

The service which such a system will render to chemists of those countries in which the general distribution of chemical literature has not yet been developed may easily be imagined. The necessity for maintaining large libraries of chemical periodicals in each country will be greatly diminished and more money can be spent for compendia and text-books. The waste due to requiring those who subscribe to chemical journals to purchase a great quantity of material which they do not use and the necessity for condensing papers to an excessive degree will be largely eliminated. Each worker under the new plan will accumulate only that which directly concerns his own research activities.

This is the germ of an idea which will no doubt be considered by many to be fantastic, especially since it is contrary to the principle of mass production developed in our own society. Our three journals can be distributed to all our members cheaper than a smaller edition of each could be sent to those who would select only one of the three. What, then, would happen if eventually the edition of our publications should be reduced to the small number of copies required to supply libraries and distributing centers? It is difficult to predict, but it is easy to imagine that multigraphing processes will be so highly developed by that time that the printing of journals devoted solely to research will not be necessary.

The project of La Maison de la Chimie and of the International Office of Chemistry must be looked upon as an experiment in the cooperative advancement of world chemistry. The exact method by which this is to be accomplished can not be predicted, but that this is the sole aim of the sponsors of the movements no fair-minded person can doubt.

American good-will has made itself felt throughout the world. Our great philanthropists who have founded such international projects as those connected with the name of Rockefeller desire to improve conditions universally, both as regards health and learning. A larger portion of their funds are expended outside of this country than within it. Surely the chemists of the United States are not less magnanimous in regard to the advancement of our science and have nothing but good wishes for the earnest efforts of every one who desires to make chemistry a more powerful factor in world progress.

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THE ULTIMATE MISSION OF CHEMISTRY

GOOD HEALTH

By CHARLES H. HERTY

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An Address before the joint meeting of the VIRGINIA SECTION, AMERICAN CHEMICAL SOCIETY, and the WOMAN'S CLUB of RICHMOND, at Richmond, Virginia, on October 21, 1927, by Chas. H. Herty, Advisor, The Chemical Foundation, Inc.

Chem. Lib.

The Ultimate Mission of Chemistry

Wrapped in mystery and secrecy, and spurred on by hope of high reward, alchemists of the Middle Ages sought in vain to discover the Philosopher's Stone, with which they hoped to transmute all baser metals into regal gold. In the sixteenth century another group of alchemists, led by Paracelsus, caught a nobler vision. Again it was the Philosopher's Stone they sought, but one whose powers would prove a universal cure for the ills of the human flesh. Though they failed, up out of this welter of mysticism, secrecy and empiricism there gradually evolved the science of Chemistry, and the modern method of scientific attack, namely, Research.

Industry was quick to recognize the value of this new tool, and through its applications in improvement of manufacturing processes, the betterment of quality, and the discovery of new compounds wealth is being created which amply repays the outlay. For industrial purposes a true Philosopher's Stone has been found, for gold is only a basis of currency, the manufacturer seeks bankable profits.

Only haltingly and all too inadequately has humanity followed the lead of the industrialists and recognized that the modern Philosopher's Stone for health is likewise research. Too often we accept sickness as a necessary evil, and a part of the heritage of mankind which must be endured. Moreover, the results of research on health are not a direct, profit-making undertaking, as is the case in industry.

Yet, entirely apart from the grief and suffering which result from ill-health and premature death, the economic losses resulting from sickness are enormous, and have been calculated with reasonable accuracy. As a result

of careful surveys by different investigators it has been found that this nation spends annually for drugs, doctors' services, interest on hospital endowments, and for hospital maintenance, a sum of not less than one billion dollars. But this expenditure is only a minor item. For light on the still greater costs we are indebted to Dr. Louis I. Dublin, chief statistician of the Metropolitan Life Insurance Company. After a thorough study of the mass of data available through this great organization, and with full explanation of how the figures are reached, Dr. Dublin has published his conviction "that sickness costs directly in lost wages, in reduced production, as well as in the necessary care, a total of two and a quarter billion dollars a year." Yet the greater losses are ahead of us, for Dr. Dublin further states: "Having due regard for the value of life at each age period, I estimate that the total capital value of the lives which can be saved annually through the application of modern preventive medicine and public-health measures is over six billion dollars."

$15,000,000,000 Losses Involved

Still more do the figures mount, for in the total we must include economic losses from those forms of sickness and disease which, despite the advances of science, must be considered as at present unpreventable. At the recent annual meeting of the American Public Health Association in Cincinnati the president, Dr. Charles V. Chapin, stated: "What is unknown about maintaining and perfecting the health of mankind is far greater than what is known. The opportunities in the scientific field are as great today as before the days of Harvey, Lister and Pasteur." It is a conservative estimate which adds another six billion dollars from this source.

What staggering figures! A total of approximately $15,000,000,000! Frankly, I cannot grasp their full significance except by comparison. There they stand,

almost the equal of our national debt, and constituting an annual loss greater than all the debts owed us by foreign countries about which we talk so much, and over which the world travails today. Fifteen billion dollars! More than two-thirds of the twenty-two billion dollars required annually for feeding the nation.

Only recently the *Manufacturers Record* set forth with justifiable pride, as illustrative of the growth of the New South, an enumeration of the costs of the many beautiful medical arts centers which have arisen in various southern cities. Do we realize that such buildings really represent the tax which our people pay because of the limitations of scientific knowledge as to the ills of the flesh?

These are not questions which concern those apart from us. They come home directly to each citizen. Look over the bottles of drugs in your medical cabinet. Consult your check books as to expenses for doctors' services. Think over the hospital charges you have incurred, and then determine whether or not this is a question which comes home directly to each of you.

Chemistry's Big Problems

Perhaps we shall think clearer if we get a new conception of what our physical bodies really are—nothing more nor less than organic chemical factories wherein the most delicate and complex reactions are occurring every moment. When these reactions are normal we feel ourselves to be in good health, efficient, and energetic, but the moment they become abnormal efficiency decreases, ambition lags, and sickness pursues its usual course of misery. Our physicians apply with skill the discoveries which science makes available to them, but after all they can only administer. Further advances must be made by the trained researchers in science.

Of all the sciences involved Chemistry is predominant, especially organic and physical chemistry. In the unit

cell the protoplasmic content brings us at once into the field of organic chemistry, and the flow of materials into and out from these cells presents intricate problems of colloid chemistry. The glands of the body are constantly producing minute quantities of hormones, organic compounds about which we know so little, yet enough to understand how deeply these secretions affect health, temperament, and emotions. The inhalation of oxygen causes changes in the blood stream which for years we have thought were well understood, yet in the light of the work done in the laboratory of the United States Public Health Service by Dr. Mansfield Clark it is probable that an entirely new interpretation will have to be given to reactions which have so long formed the basis of physiological diagnoses. The disruption of chemical equilibria within our bodies results in many important changes; perhaps the final explanation for the common cold lies just here. In health organic reactions are taking place under normal velocities, but when by some catalytic agency these reactions are accelerated or retarded, trouble begins. Hydrogen-ion concentration is a term in daily use in all biochemical laboratories. I need but mention the beneficent services of chemo-therapy in furnishing far-reaching specific cures. Bear in mind how little we know as yet about the vitamines. The varying recommendations as to diet, from year to year, reveal the many unsolved questions in metabolism. Problems of all sorts confront us. One's body is a chemical factory which through its very nature makes intensely difficult the research necessary to solve these problems, but is there anyone who in his heart doubts the eventual ability of science to find the solutions?

The very difficulties make all the more urgent a determined and comprehensive attack. I would not utter one word to detract from the high praise due those

already at work in this field. In our universities men and women are giving unselfishly of their time, energy, and enthusiasm, yet after all such work is in most cases secondary to their teaching duties, and all too frequently funds for experimental equipment are pitifully small. Moreover, in many cases such work is all too isolated, too individualistic. In endowed institutions, made possible by the generosity of men of wealth, scientists are giving their entire time, but the number of such institutions is very limited, while the problems are legion.

The Hospital's Function?

In a few, but only a few, of our hospitals there is a linking up of the clinical evidence with the fundamental point of view of the scientists. Some day that situation will be changed. Are our hospital authorities content with supplying beds and medical advice for an unending stream of the sick? Will they not catch the larger vision that from these sick beds science can gain inestimable help in preventing those now well from undertaking so sad a journey?

No one will testify more willingly than physicians themselves to the fundamental importance of chemistry in the cure of sickness. They were once students in medical colleges. A glance at the curricula of those times readily explains the lack of knowledge of chemistry on the part of the physician in his daily practice, but he knows that it is chemistry that is needed, and he is seeking that aid. But, like the industrialist of a decade ago, he all too frequently uses the chemist merely as a routine analyst. The industrialist still uses the analytical chemist, but his loud clamor today is for the research chemist. So must it be in medicine.

The research chemist will tell you immediately that his work alone does not suffice. Co-operation of all branches of science is required. The chemist, the bacteri-

ologist, the pharmacologist, the physicist, the clinician, must work side by side if truth is to be reached quickly. Happily that spirit of co-operation is increasing. It should be fostered.

Whence will come the supply of chemists adequately trained for this all-important service? Naturally, from our universities. In a recent survey of the lines of chemical research in progress by graduate students, the National Research Council finds that of the 1882 graduate students in Chemistry, 475 are in the field of organic chemistry, and 207 in physiological chemistry. If we add those who are specializing in colloid chemistry, in catalysis, in pharmacological, pharmaceutical, sanitary, and food chemistry, we see at once how large a proportion of trained men and women will leave our universities in the next few years equipped for this line of research. One of the greatest benefits of the establishment of a complete organic chemical industry in this country since the war is the directive tendency toward research which can be applied equally for wealth or for health.

Popular Action Necessary

Researchers, however, cannot live by enthusiasm alone; they must be paid at least a decent living wage. From what sources may we expect that financial aid which will enable this increasing army waging the battle against disease to function efficiently? We can look forward confidently to the founding of more and greater endowed institutions. The continued growth of the graduate schools of our universities means the multiplication of the hands and the time of able professors. But after all, is it the true American spirit which would lead us to be content to await the largess of the rich or the devoted enthusiasm of professorial staffs in order to remove through scientific research this financial drain upon each of us as individual citizens? No! In other

lines of financial betterment we do not sit idly by, twitting our thumbs and waiting for a legacy from some rich citizen unknown to us, or trusting that some generous friend will share with us the product of his brain. We are proud of the fact that we hustle for ourselves, and we count as our most precious heritage that independent spirit which leads us to look after our own business. Invoking the same spirit of independence, I say to you that since we are all subject to sickness, since ill-health is characteristic of no particular section, and is no respecter of age, sex, or position in life, the financing of research for better health is a matter for united action by all our people.

Fortunately it is not necessary to make a house to house campaign to solicit funds for such an undertaking. The machinery is already provided—appropriations by Congress from the federal taxes. This method is already being utilized for the ailments of business through the splendid work of the Department of Commerce; for the sickness of crops and livestock in the energetic laboratories of the Department of Agriculture. When the corn borer threatened this great staple crop the last Congress, in a jiffy, appropriated $10,000,000 for its extermination. Hogs and cows receive their full meed of attention from the national community chest—but oh how pitiful in comparison are the appropriations for scientific research on the ills of the human flesh. Remembering that these problems are fundamentally chemical, it will doubtless amaze you to learn that of the many millions of public funds appropriated last year only thirty to forty thousand dollars were available for the chemical research work of the Hygienic Laboratory of the United States Public Health Service, in contrast with the ten million dollars for the corn borer, and in the face of an annual economic loss through sickness of $15,000,000,000. And this in a day when

every tongue is loud in praise of the wonderful accomplishments of science.

The Ransdell Bill

Hon. Joseph E. Ransdell, United States Senator from Louisiana, has seen the light. In the closing days of the last session he introduced a measure which aims to correct this situation. He proposes to reintroduce this bill immediately after the opening of Congress in December; hearings will be held and the measure will be vigorously pushed.

The Ransdell bill, S. 5835, provides for the creation of a National Institute of Health within the U. S. Public Health Service. No new administrative body is contemplated, the Institute constituting an integral part of the Public Health Service, a branch of the government service which has always been held in high esteem for its efficiency. An appropriation is included adequate for the construction of suitable buildings, and for equipment and maintenance. A system of fellowships will enable trained researchers to pursue investigations either in Washington or at distant points in this country or foreign lands, wherever the problem can be worked upon best. Acceptance by the Public Health Service of gifts from individuals who wish to endow specific lines of research is authorized. The bill includes all of the provisions of the Parker bill, H. R. 10125, a measure which seeks greater efficiency in government health work by combining all of these activities within the Public Health Service.

Unanimous Endorsements

Senator Ransdell's bill received the unanimous endorsement of the organized physicians of the country, the American Medical Association, at the annual meeting in Washington in May of this year. Just a few days ago in Cincinnati it received similar approval from the

American Public Health Association, while the American Chemical Society started the wave of popular approval by a unanimous vote of the Council at Richmond, Va., last spring.

What possible obstacles will confront the bill when it comes up for action by the next Congress?

First: A lack of understanding on the part of members of Congress. As citizens it is our duty to see that our lawmakers are informed regarding the situation and its remedy.

Second: The economy program of the Administration. But surely it would be false economy to refuse to spend a few million dollars in order to save the billions now being sacrificed.

Third: Flood control will be in the forefront of the thoughts of every member of Congress. Rightly so, for the recent Mississippi flood with its attendant loss of life and of property estimated at from $250,000,000 to $500,000,000 was a national disaster, and the avoidance of its recurrence is a national responsibility. The rush of those mighty waters awoke us to our duty. The ravages of sickness and disease, however, are confined to the quiet bed-room, and so ubiquitous are these afflictions that they do not constitute news. Devastating floods come only at intervals, but the far greater economic losses from ill-health are continuous. These billions are entirely apart from the suffering and sorrow which no power of mathematics can estimate. From out these shadows science can lead the way to light. With conviction in your hearts, speed the day when America shall make this great contribution to humanity.

Endorsements of the Bill

American Chemical Society

Extract from the Proceedings of the Council, Richmond, Va., April 11, 1927:

The Chairman offered the following resolution, which was unanimously passed:

WHEREAS the prevalence of sickness among our people, with attendant suffering and economic losses, points clearly to the need of a greater amount of fundamental research for the alleviation of this condition, and

WHEREAS all are subject to sickness, all should participate in providing for this necessary fundamental research, therefore be it

Resolved that the Council of the AMERICAN CHEMICAL SOCIETY approves the principles embodied in the bill, S. 5835, introduced in the 69th Congress by Senator Ransdell, providing for a National Institute of Health and for needed administrative reforms in the United States Public Health Service, and urges its early and favorable consideration by the 70th Congress.

American Medical Association

Extract from the Proceedings of the Washington Session, House of Delegates, May 18, 1927:

Dr. E. J. Goodwin, Missouri, read a supplementary report of the Reference Committee on Legislation and Public Relations:

1. The reference committee recommends that the House of Delegates reaffirm its approval in principle of the Parker bill approved at the Dallas session, co-ordinating all public health activities of the federal government under the direction of the United States Public Health Service. We also recommend the approval of the Ransdell bill, which is identical with the Parker bill excepting that the Ransdell bill appropriates $10,000,000 to establish and operate a national institute of health under the control of the Surgeon General of the Public Health Service.

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The report as a whole was adopted on motion of Dr. Goodwin, seconded by Dr. A. T. McCormack, Kentucky.

AMERICAN PUBLIC HEALTH ASSOCIATION

Resolution passed by the Governing Council at Cincinnati, Ohio, October 19, 1927:

Recognizing the need for thoroughly co-ordinated efforts on the part of all government agencies concerned with questions of public health, and

Convinced that fundamental research is the necessary foundation for all progress in health problems, therefore be it

Resolved that the AMERICAN PUBLIC HEALTH ASSOCIATION hereby approves the principles of the Ransdell bill, S. 5835, introduced in the Senate of the sixty-ninth Congress of the United States on March 2, 1927.

The Ransdell Bill

IN THE SENATE OF THE UNITED STATES, March 2 (calendar day, March 3), 1927, MR. RANSDELL introduced the following bill; which was read twice and referred to the Committee on Commerce:

*A bill (S. 5835) to establish a National Institute of Health, to authorize increased appropriations for the Hygienic Laboratory, and to authorize the Government to accept donations for use in ascertaining the cause, prevention, and cure of disease affecting human beings, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

That whenever the President finds that it will promote greater efficiency in the conduct of the public health activities of the Government, he is authorized, by Executive order, to transfer to the Public Health Service all or any part of any executive agency (other than an agency of the military or naval forces, the War Department, the Navy Department, or the United States Veterans' Bureau) engaged in carrying on a public-health activity. Any such Executive order shall also designate the records, property (including office equipment), personnel, and unexpended balance of appropriations to be transferred.

SEC. 2. (a) The President is authorized, by Executive order, to direct that officers or employees of the Public Health Service shall be detailed to any other executive agency which is carrying on a public-health activity in order to supervise or co-operate in such work.

(b) Upon the request of the head of an executive department or an independent establishment which is carrying on a public-health activity, the Surgeon General of the Public Health Service is authorized to detail officers or employees of the Public Health Service to such department or independent establishment in order to supervise or co-operate in such work.

SEC. 3. (a) The Surgeon General of the Public Health Service is authorized to detail medical or scientific personnel of the Public Health Service to educational and research institutions for special studies of scientific problems relating to public health and for the dissemination of information relating to public health, and to extend the facilities of the Hygienic Laboratory to health officials and scientists engaged in special study.

(b) The Secretary of the Treasury is authorized to establish such additional divisions in the Hygienic Laboratory as he deems

*Reintroduced December 9, 1927, as S. 871.

necessary to provide agencies for the solution of public-health problems and facilities for the co-ordination of research of public-health officials and scientists and for demonstrations of sanitary methods and appliances.

(c) The Secretary of the Treasury is authorized to establish and operate a National Institute of Health under the jurisdiction of his department and the administrative control of the Surgeon General of the Public Health Service which shall be devoted to scientific research in the fundamental problems of the diseases of man and matters pertaining thereto. The Secretary is authorized to select a site on land owned by the Government and available for this purpose, or to acquire a site by purchase, condemnation, or otherwise, in or near the District of Columbia, and to erect thereon suitable and necessary buildings, including furniture and equipment for the use of such institute. In the administration and operation of this institute the Surgeon General shall select persons who show unusual aptitude in science. The Surgeon General, with the approval of the Secretary of the Treasury, may make such rules and regulations for the government and administration of such institute as he deems advisable. There is hereby authorized to be appropriated, out of any money in the Treasury not otherwise appropriated, the sum of $10,000,000, or so much thereof as may be necessary to carry out the provisions of this paragraph.

SEC. 4. (a) The President is authorized to transmit to Congress through the Bureau of the Budget estimates of the amounts necessary for the construction on the site now occupied by the Hygienic Laboratory of buildings adequate for the Public Health Service, also estimates for amounts necessary in connection with the establishment and operation of the National Institute of Health described in the foregoing section, together with such other amounts as he may deem necessary to carry out the objects and purposes of this Act.

(b) The administrative office and bureau divisions of the Public Health Service in the District of Columbia shall be administered as a part of the departmental organization, and the scientific offices and research laboratories of the Public Health Service (whether or not in the District of Columbia) shall be administered as a part of the field service.

(c) The Secretary of the Treasury is authorized to accept, on behalf of the United States, gifts by will or otherwise for study, investigation, and research in the fundamental problems of the diseases of man and matters pertaining thereto. Any such gifts shall be held in trust, and shall be invested by the Secretary of the Treasury in securities of the United States, and the income thereof

shall be administered by the Surgeon General for the purposes indicated in this Act. The Surgeon General is authorized to establish fellowships in the Hygienic Laboratory and the National Institute of Health, and utilize the proceeds thereof in aid of individual scientists who have demonstrated or give promise of marked proficiency in research and investigations relating to the diseases of man. Gifts in the amount of $500,000 or more shall bear the name of the donor.

(d) Individual scientists designated by the Surgeon General to receive fellowships may be appointed for duty in the Hygienic Laboratory and the National Institute of Health established by this Act. During the period of such fellowship, these appointees shall hold appointments under regulations promulgated by the Secretary of the Treasury, and shall be subject to administrative regulations for the conduct of the Public Health Service. Scientists so selected may likewise be designated for the prosecution of investigations in other localities and institutions in this and other countries during the term of their fellowships.

SEC. 5. (a) Hereafter sanitary engineers, dental officers, and scientists of the Public Health Service, selected for general service and subject to changes of station, shall be appointed by the President, by and with the advice and consent of the Senate, subject to the same conditions and limitations as medical officers of the Public Health Service, except that—

(1) Examinations shall be in the several branches of the profession of the person to be appointed;

(2) Any sanitary engineer, medical, dental, or other scientific officer in the Public Health Service upon the date of passage of this Act, or transferred to the Public Health Service under the authority of this Act, after examination by a board of officers convened by the Surgeon General of the Public Health Service, and upon the recommendation of such board and the Surgeon General, may be appointed to any grade designated by such board and approved by the Surgeon General; and in computing longevity pay and pay period the service of any such officer shall be counted in the same manner as though he were in the service on June 30, 1922; and

(3) Whenever in the opinion of the Surgeon General of the Public Health Service commissioned officers are not available for the performance of permanent duties requiring highly specialized training and experience in scientific research, including the duties of chiefs of divisions of the Hygienic Laboratory, any person, after examination by a board of officers convened by the Surgeon General of the Public Health Service and upon the recommendation of such board and the Surgeon General, may be appointed to any grade

designated by such board and approved by the Surgeon General.

(b) The Surgeon General of the Public Health Service shall designate the grades of commissioned officers of the Public Health Service other than medical officers, corresponding to the grades of medical officers.

(c) Hereafter commissioned officers of the Public Health Service shall be entitled to promotion according to the same length of service as officers of corresponding grades of the Medical Corps of the Army, and the Surgeon General of the Public Health Service shall have the equivalent rank of, and shall be entitled to the same pay and allowance as, the Surgeon General of the Army.

(d) The limitation now imposed upon the number of Assistant Surgeons General and senior surgeons of the Public Health Service, on active duty, is hereby repealed.

(e) Hereafter officers of the Public Health Service in the grade of Assistant Surgeon General on field service shall be designated and known as medical directors.

SEC. 6. Hereafter the Secretary of the Treasury shall appoint, in accordance with the civil service laws, all officers and employees, other than commissioned officers, of the Public Health Service, and may make any such appointment effective as of the date on which the officer or employee enters upon duty.

SEC. 7. There is hereby established in the Public Health Service a nurse corps, which shall consist of a superintendent and such other nurses as the Secretary of the Treasury may deem necessary. The members of the nurse corps shall be entitled to receive the same pay and allowances as nurses of the Army.

SEC. 8. Hereafter the advisory board for the Hygienic Laboratory shall be known as the National Advisory Health Council, and the Surgeon General of the Public Health Service, with the approval of the Secretary of the Treasury, is authorized to appoint, from representatives of the public-health profession, five additional members of such council. The terms of service, compensation, and allowances of such additional members shall be the same as the other members of such council not in the regular employment of the Government, except that the terms of service of the members first appointed shall be so arranged that the terms of not more than two members shall expire each year. Such council, in addition to its other functions, shall advise the Surgeon General of the Public Health Service in respect of public-health activities.

SEC. 9. As used in this Act, the term "executive agency" means any board, bureau, division, service, or office in the executive branch of the Government.